Transforming Joint Air and Space Power

The Journal of the JAPCC

15th ANNIVERSARY

Edition 30, Spring/Summer 2020

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Editorial

Our world has faced a challenging last few months in this first half of 2020. The Covid-19 pandemic influenced every area of our daily lives and did not spare the Air & Space Power Community. After celebrating our 15th Anniversary, the JAPCC is now challenged by the restrictions resulting from the current worldwide situation. The Steering Committee in June was held via Video Conference and the 2020 Joint Air and Space Power conference is postponed to December. Defying the challenges, the members of the JAPCC continue working at their offices or from home, providing you with effective solutions and food for thought on Air & Space Power Challenges.

Therefore it is my distinct pleasure to present to you the 30th Edition of the 'Journal of the JAPCC'. We have a variety of articles in our '15th Anniversary Edition' that will offer you some interesting reads during this exceptional time. Our former Director and current SACEUR General Tod D. Wolters starts off by highlighting the importance of comprehensive readiness for the 21st century. The Chief of the German Air Force Lieutenant General Ingo Gerhartz, provides us four very interesting theses on how to approach future all-domain challenges, stimulating an open dialogue.

In the following article Major General Phillip Stewart presents the capabilities and benefits to NATO of the 'Alliance Ground Surveillance Force'. Major General Juan P. Sánchez de Lara provides a Spanish view of the 'Space Situational Awareness' challenges and 'The Case of PEGASUS' gives a university perspective on the development of competences for Space Power. Subsequent articles discuss the 'State's Right to Self-Defence in Outer Space', the 'Arctic Space Challenge for NATO Emerging from China's Economic and Financial Assertiveness' and 'Using the Space Domain' from an ISR perspective. We are moving from Space back to the Earth with 'Air-Land Integration – NATO's Strategic Joint Challenge' and 'The New Aircraft Cross-Servicing Programme of NATO'. The article 'Hybrid/Electric Aero-Propulsion' highlights the challenges and benefits of possible future propulsion solutions. 'The Future of Air Power and the Future of European Defence Industry' takes a critical look into the modernization of air forces and the role of a competitive European arms industry. The Journal then moves on to different view Points on 'Cyber-Electromagnetic Domain' and 'The Importance of Integrated Air and Missile Defence Training'. Finally we want to highlight the 'NATO SEAD Course' trying to repair the NATO SEAD knowledge gap, which was highlighted in a previous Journal article.

Thank you for taking the time to read the 'Anniversary Edition' of our Journal, and thanks to our authors for their contributions. I hope you find this offering as informative and thought-provoking as I did. We at the JAPCC greatly appreciate your feedback and thoughts and we welcome discussion about the published articles. The JAPCC has successfully increased its social presence over the last years, which you can read more about in of the 'Inside the JAPCC' articles. Please visit our website www.japcc.org, like us on LinkedIn or Facebook, follow us on Twitter or send us an e-mail to contact@japcc.org to give us your opinion.

Ciao and good reading!

Giuseppe Sgamba
Brigadier General, IT AF
Assistant Director, JAPCC

The Journal of the JAPCC welcomes unsolicited manuscripts.
Please e-mail submissions to: contact@japcc.org

We encourage comments on the articles in order to promote discussion concerning Air and Space Power.

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Gen Jeffrey L. Harrigian

Executive Director
Joint Air Power Competence Centre
Lt Gen Klaus Habersetzer

Editor
Brig Gen Giuseppe Sgamba

Assistant Editor
Lt Col Daniel Wagner

Production Manager/
Advertising Manager
Mr Simon J. Ingram

Editorial Review Team
Col Brad Bredenkamp
Lt Col Henry Heren
Lt Col Panagiotis Stathopoulos
Mr Adam T. Jux

Purpose
The JAPCC Journal aims to serve as a forum for the presentation and stimulation of innovative thinking about strategic, operational and tactical aspects of Joint Air and Space Power. These include capability development, concept and doctrine, techniques and procedures, interoperability, exercise and training, force structure and readiness, etc.

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Vigilance Must Endure

Comprehensive Readiness for the 21st Century

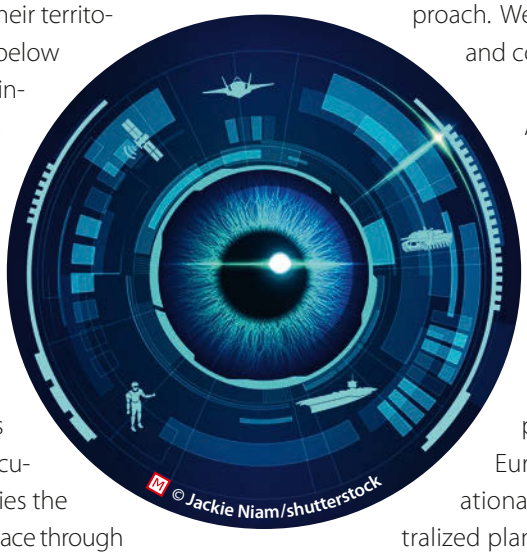
By General Tod D. Wolters, US Air Force, SACEUR

New Threats and Challenges to the Alliance

NATO's comprehensive deterrence and defence activities continue to sustain peace and defend the sovereignty of member nations across the Euro-Atlantic area with overwhelming success. However, we must maintain positive campaign momentum with respect to our speed, stance, and readiness. This relentless pursuit is required to maintain our competitive edge in an ever-changing security environment. Threats and challenges are stressing the rules-based

international order and seeking advantage through the application of various instruments of power, backed by increasingly capable forces.

We face a much-changed security environment and a more unpredictable world. The sovereignty of NATO nations and the means to secure their territorial integrity are being confronted below the level of armed conflict. Continued malign information activities and exploitation of free access to Western economies are some ways challengers are attempting to seek advantage. Unchecked, these activities could escalate into more aggressive behaviour. NATO's new Military Strategy of 2019 acknowledges these challenges and clearly articulates the enduring vigilance activities the Alliance must embrace to sustain peace through comprehensive deterrence and defence.



Comprehensive 360-degree Deterrence and Defence

The Alliance has already implemented a multitude of decisive actions to address these new challenges. NATO has established two new military headquarters, Joint Force Command Norfolk in the US and Joint Support and Enabling Command in Ulm, Germany to strengthen transatlantic lines of communication and rear area logistics coordination in Europe. These headquarters increase our ability to command and control, enable deployment, and sustain NATO forces in crisis through conflict. We have also made progress in improving infrastructure and transit procedures to facilitate the rapid movement of forces. While we have modified Exercise Defender-Europe 2020 as part of prudent efforts to minimize the spread of COVID-19, coordination, planning, and much of the logistics work still occurred. Though modified, this major exercise provided the opportunity to demonstrate capability, evaluate our procedures, and to identify areas for further improvement. Through continued alert and air policing activities, our standing maritime groups, and our forward presence of land battle groups … we have considerably improved our all-domain security, awareness, and indications and warnings. NATO's formal declaration of space as an operational domain offers tremendous implications for other domains and adds to our comprehensive thinking and approach. We have heightened our readiness and continue to improve our posture.

Allied Command Operations has taken measures to improve our posture in the information domain as well. Our nations are improving alignment with whole-of-government activities. In cyberspace, the Cyber Operations Centre at the Supreme Headquarters Allied Powers Europe (SHAPE) enhances our situational awareness and provides centralized planning and command and control for cyberspace aspects of Alliance operations and missions. Dedicated educational efforts, agreement on integration of sovereign cyber effects, efforts to improve the hygiene of our networks, and increased resilience of our command and control nodes have all improved our vigilance in this ubiquitous 21st century domain.

Pushing Posture, Speed, and Readiness to the Highest Prudent Levels

In all domains – air, land, sea, space, and cyber – we must continue to explore ways to ensure our ability to deliver effects quicker than ever before. We must continue to present our capabilities and forces in unique and unpredictable ways to enable simultaneous all-domain action. Pushing comprehensive readiness to the highest prudent levels, and being able to employ our capabilities faster than our threats or challengers is the most potent way to communicate our resolve and sustain peace.

To ensure the further development of our capabilities while improving NATO's training, readiness and responsiveness, it is of utmost importance for NATO's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Centres of Excellence (CoE), such as the Joint Air Power Competence Centre (JAPCC), to continue their outstanding work. Innovative thoughts, concepts, and well-founded recommendations to address developments in the Air and Space domains are foundational for delivering decisive effects. We must leverage our CoEs to do heavy thinking on the critical questions of today and tomorrow. How do we enhance our ability to ensure effective Command and Control (C2) in a joint, all-domain environment? How can Artificial Intelligence support military planning? How can the handling of *big data* play an essential role in enabling a rapid response across the peace, crisis, and conflict spectrum? The answers to these questions require much thought, and effort … but are vital to maintaining our competitive advantage. Our ability to preserve security for the one billion people we are sworn to protect depends on the quality of these answers and our action on these questions and more.

Effective Solutions for Air and Space Power Challenges

Established 15 years ago in 2005, the JAPCC is the Alliance's oldest and first accredited CoE. At its founding, JAPCC was chartered to support the transformation of NATO Air and Space Power. To enable this important effort, a unique organizational construct was established linking the operational and tactical level command of NATO's air capabilities at Headquarters Allied Air Command (HQ AIRCOM) in Ramstein and the Combined Air Operations Centre (CAOC) Uedem, to the CoE. Over the years, the JAPCC has fully matured into a well-versed centre of expertise, delivering valuable contributions to the development of NATO concepts and doctrine. The JAPCC's annual Air and Space Power Conference, as well as the variety of its publications, offer opportunities to the Air and Space community to exchange thoughts, assessments, and perspectives.

These forums, the conceptual thought, and doctrinal work of the CoE reinforce JAPCC's mission, *to offer independent thought and provide effective solutions to Air and Space Power challenges as a basis for well-informed decisions by leaders of NATO and our nations.* We have no doubt the JAPCC will continue to be a game-winning advantage for our development of the Alliance's Air and Space capabilities for years to come. These concepts and advice are equally relevant to leaders and operators alike.

On behalf of the men and women of Allied Command Operations, we offer our deepest gratitude to the members of the JAPCC for their dedicated work and congratulate this world-class team on 15 years of great work. Stay the course!

General Tod D. Wolters

assumed duties as NATO's 19th Supreme Allied Commander Europe (SACEUR) on May 3, 2019. As SACEUR, he is one of NATO's two strategic commanders and commands Allied Command Operations (ACO), which is responsible for the planning and execution of all Alliance operations. He is responsible to NATO's Military Committee for the conduct of all NATO military operations.

General Wolters previously served as Commander Allied Air Command; Commander, US Air Forces in Europe; Commander, US Air Forces Africa, headquartered at Ramstein Air Base, Germany, and Director, Joint Air Power Competence Centre, Kalkar, Germany.

The Luftwaffe in Multi-Domain Operations

By Lieutenant General Ingo Gerhartz, Chief of the German Air Force

Introduction

NATO is living through one of the most challenging periods of its existence. Our security environment has become even more complex and increasingly dynamic. Our security situation is characterized by crises, conflicts and the revival of traditional power policies. The upcoming decades require extraordinary capabilities of civil and military interagency cooperation and capacities to fight and win in an increasingly multi-domain information battlespace.

Today's challenges require a shared vision of how we will shape our national forces and NATO beyond branch barriers for joint all-domain operations. For NATO to maintain its status of being able to respond to all security challenges it must continue to understand the multi-domain battlespace.

The Joint Air & Space Power Conference hosted annually by the Joint Air Power Competence Centre (JAPCC) has established itself as an internationally recognized open-discussion forum on relevant issues for the Alliance. The subject 'Multi-Domain Operations' was the perfect focus of the JAPCC Conference 2019: Which challenges does the transatlantic Alliance face in order to meet the requirements? What are the future enablers to cope with these challenges?

Keynotes, panel discussions and side-talks emphasized our common interest in further pushing ahead with our common understanding. What we need is a shared vision on the definition and the requirements of a multi-domain operation.

The side-talks with speakers, panellists and participants were informative and enlightening. The face-to-face

Portrait: © Luftwaffe, Francis Hildemann; Flag: patrice6000/shutterstock

meetings with General Jeffrey L. Harrigian, Lieutenant General David D. Thompson together with Lieutenant General Klaus Habersetzer were of utmost importance.

The JAPCC Conference was an outstanding opportunity not only to meet old friends and make new ones but also to discuss important issues. My keynote was the starting point of the second conference day taking up the results already achieved.

Key Factors Addressing the Transition Towards Multi-Domain Operations

Cooperation and interoperability are in our DNA within our service. For airmen, thinking in multi-domain operations is nothing unusual. Our service was born from airpower's promise of combat effects that could enable success on the whole battlefield. It is part of our culture. However, thinking in a multi-domain culture is not the same as creating kinetic and non-kinetic effects from different partner nations in different domains, time-spaced by seconds and having immediate contingency effects ready for individual missed or denied targets.

Therefore, 'joint' and 'combined' is not the same as an 'effects-based synchronized' tactical integrated all-domain mission. The new Luftwaffe rule of thumb is 'single-domain planning will definitely prevent proper performance'.

Even though operations within a multi-domain environment are nothing new, 'real-time integrated' manoeuvres on a tactical level between air, land, sea forces or cyber and space elements are still a challenge, especially for a coalition of nations like NATO. The German Air Force is well aware of its responsibility – not just for the domain air!

The following four theses cover a wide spectrum and highlight the key factors that determine how we will master the transition towards multi-domain operations and Command and Control (C2).

JAPCC Journal readers and all-domain experts can take these theses as my offer for an open dialogue. Dig into them, add your comments, and either agree or prove them wrong in your papers on joint all-domain operations/C2.

We must understand the significance of the lingering merger of our dimensions into that all-domain principle.

Command and control, structure, organization, communication and weapon systems – all areas are equally affected.

In particular: Cyber and space are crucial to all other domains. It is time for us, regardless of our specialty badges, to embrace space and cyber superiority with the same passion and sense of ownership as we apply to air superiority today.

Cyber has unique warfighting capabilities and is of interest because the barriers and entry costs tend to be lower. Cyber actors can change their environment to both their advantage and their enemies' disadvantage.

Space actors have direct contact and access to all traditional domains.

The cyber and space domains have a very dynamic and extensive nature, and the future of our security depends on the space and cyber domains and their integration into the existing construct. Their usage will further merge the traditional domains land, air and sea and will further raise the operational tempo.

The time to integrate the space and cyber domains into our operational mindset is NOW. Last year NATO adapted the 'Overarching Space Policy' and acknowledged space as an operational domain. Right now, we deliberate on the resulting consequences in all areas. As we need excellent expertise to fuel our current decision-making I think it is time to officially recognize the work of the JAPCC on Space matters for NATO since the Centre's establishment 15 years ago and formalize a role the JAPCC has occupied since the beginning as 'NATO's Centre of Excellence (CoE) for Space'.

We must be prepared to give up our traditional way of thinking.

Traditionally, armed forces – and air forces, too – have focused on the physical and direct effect. Furthermore, we just recognized the importance of space and cyber usage. However, the underlying element, which holds it all together or separates domains by denying access, is the electromagnetic spectrum.

What will be more important in the future than the performance data and the speed of our fighter aircraft is the question whether the data transmission rate is high enough to respond to a new 'character' of warfare, and whether we can protect the data transmission and sensors' field of view within and across domains? In this context we have identified electronic warfare as enabler, dependency and one of the top priorities.

We must continue to modify the way we think to further include the capabilities and contributions of forces from all domains – air, space, cyberspace, maritime, land – and therefore protect and dominate the electromagnetic spectrum.

As an example, we can think about the increased importance of escort and stand-in jamming, up to a sophisticated art and tactics with dedicated assets within air operation and as top cover for land units and sea platforms.

These assets are the indispensable enablers even for 5th generation jets to gain and sustain multi-domain control from the air for a certain time and 3D range.

Airborne electronic attack assets have to fight an intensive digital war to provide that tactical multi-domain bubble for others to use freedom of movement.

Furthermore – if we want to burst the all-domain Anti Access/Aerial Denial (A2AD) bubble, we need tactical integrated multi-domain Intelligence, Surveillance and Reconnaissance (ISR) at the front line. Modern ISR and battlefield connectivity are the heat that melts the kill chain to its shortest possible length. But both are only effective if we can protect their electromagnetic environment.

JAPCC Joint Air & Space Power Conference, October 2019.

Our C2 needs a new 'driver's seat'. C2 must be ready to give up the traditional way of thinking and leave behind the well-trodden and rigidly hierarchical command structure at all levels, and we have to enable and allow the weapons system level to fight across domains in real-time.

In the future air battle, a 72 hours Ops cycle will likely be too long and an 'Air' Task Order might rather become a 'Synchronized' Task Order.

We need C2 command and control that permits smooth transitions between support and supporting roles and allows scalable distributed control and execution. The air dimension might be the perfect one to provide the tactical part of 'distributed control' if we manage to own the electromagnetic environment. We need a new level of operational agility, in both planning and execution.

Multi-domain C2 requires dynamic action at the tactical level. Agile decision-making is critical to the success of joint all-domain integration and can be achieved only in a culture of bottom-up innovation and bold leadership.

In the area of information processing, C2 needs to take a new approach.

The air force can generate an immense amount of data. But much of this data is often of little sense or utility to a fused picture in the conduct of operations.

The big question is what information should be shared, and with whom, to best enable the delivery of the right effect at the right place at the right time. Is it sensor-, data- or info-, meaning low-, mid- or high-level fusion, which is needed between which assets and with which level of integration? That will be the crucial question for the Future Combat Air System (FCAS).

The aspect of multi-domain operations must be considered in the development of all new systems, while we must not forget or neglect those systems that do not fully meet the modern technological requirements.

With our Next Generation Fighter we will open up options for specific applications featuring unmanned platforms, teaming and swarming.

It is obvious that we need a level of connectivity that is consistently designed to make multi-domain operations possible. Our level of ambition is to push forward our capabilities, not building up complexity of planning and fighting.

The demands are high and the Luftwaffe focuses on sophisticated and innovative cutting-edge technology.

Within the scope of the overall system, a new command fighter will be complemented by 4th generation legacy fighters like the 'Eurofighter', 'Rafale', 'Hornet' or the 'Gripen'.

As a coalition, as NATO, we will only be able to unfold our full potential if we manage to integrate older weapon systems effectively and seamlessly into the multi-domain concept.

In this spirit, multi-domain operations will tie us even closer together. Only together will we be able to tackle the enormous and dynamic security challenges.

The participation in international exercises is a suitable way to achieve this goal. Multinational cooperation is the basis of interoperability – and interoperability is decisive for acting in joint all-domain operations.

We need both – a vision, but also the persistence to take many small steps.

The Luftwaffe, as well as NATO, already established a guiding idea, a vision that defines the long-term goals.

We need an integrated all-domain strategy that makes it unmistakably clear that 'Multi-Domain Operations' is more than a 'slogan' based on an unrealistic ambition; it is the predicted, and indeed the unavoidable, solution.

The success of multi-domain integration will depend on whether we share information, but also whether we cooperate in early testing and technology development.

What we need as much as a vision is a pragmatic short and medium-term approach. With many small steps we can turn visionary dreams into a real solution. That way we can produce visible progress and solutions for the most important resource of our forces: our personnel.

Education, training and leadership will have to evolve to guarantee that our personnel have the necessary knowledge and skills to understand the implications of an all-domain battlespace.

Multi-domain operation requires dynamic action at all levels. Operators must have not only the skill to perform their own mission in one domain. They must also understand how operators of other domains assure their mission accomplishment.

Moving forward, training and education will be key. It is important to train our airmen in a multi-domain manner from the beginning of their careers.

'I congratulate the JAPCC Team for this outstanding success.'

The Luftwaffe is opening its planning room doors to army, navy, cyber forces, allies and partners. We are prepared and willing to proceed to the future.

15th Anniversary of JAPCC

The 'Joint Air & Space Power Conference 2019' focusing on 'Multi-Domain Operations' perfectly hit the nerve of the time, once again confirming that the JAPCC is delivering valuable contributions to the future of NATO.

The JAPCC is NATO's first accredited Centre of Excellence. For 15 years, JAPCC has been recognized as a driving force of NATO Air and Space Power. I congratulate the JAPCC Team for this outstanding success. Maintain your spirit with pride and continue this positive work.

Lieutenant General Ingo Gerhartz

joined the Bundeswehr in July 1985 and completed his jet pilot training at Sheppard Air Force Base in 1989 and weapon system training in 1990.

He spent the following eight years as a fighter pilot and Operations Staff Officer with the 71 Fighter Wing 'Richthofen'. Between 2000 and 2003, was assigned to 73 Fighter Wing 'Steinhoff' at Laage as Commander, Flying Group. During his assignment as Commander to Fighter Bomber Wing 31 'Boelcke' he spent eight months on the ISAF mission as Air Wing Commander and Base Commander of Camp Marmal in Afghanistan. As a command pilot, he flew over 2,500 hours in the F4, TORNADO, MIG29 and EUROFIGHTER and participated in more than 50 combat missions. In June 2018, he was promoted to Lieutenant General and simultaneously took office as Chief of the German Air Force.

Alliance Ground Surveillance Force

NATO's Premier, Multi-Domain Intelligence, Surveillance & Reconnaissance System

By Major General Phillip Stewart, NATO Alliance Ground Surveillance Force Commander

Introduction

The NATO Alliance Ground Surveillance Force (NAGSF) is a 'quantum leap' in NATO's Intelligence, Surveillance & Reconnaissance (ISR) capabilities, with unprecedented integration to benefit NATO and all 30 Alliance nations. It is the world's most advanced *integrated* air-ground surveillance system, due to its unique combination of multi-domain intelligence operations expeditionary and reach-back Processing, Exploitation, and Dissemination (PED) capabilities, on-site schoolhouse and experienced multinational team, with military and civilian experts from across the Alliance.

NAGSF has multiple capabilities, including five Global Hawk (RQ-4D) 'Phoenix' aircraft for organic collection; a robust PED element capable of both fixed and expeditionary operations and an organic training centre that covers all major functions within the organization. NAGSF embodies NATO's continued commitment to strengthen our deterrence and defence readiness and will be active throughout the Joint ISR environment.

Aircraft

The NAGSF aircraft are large, highly advanced ISR platforms with unmatched operational altitude, sensor standoff, and mission endurance. Launching from Sigonella Air Base, Italy, the aircraft will execute missions between 50,000–60,000 feet within friendly and/or international airspace, utilizing their Synthetic Aperture Radar (SAR) to collect imagery and ground movement data throughout their over 30-hour flight duration.

The sensors on the NAGSF aircraft provide an all-weather, wide-area collection capability that perfectly complements the airframe's high operational altitude and supreme endurance. Due to the sensor's ability to collect imagery and track movement deep within contested or denied territory, the aircraft can effectively collect on targets and surveil wide areas while remaining in non-hostile airspace. The aircraft have Link-16 capability for improved situational awareness and an Automatic Identification System, which affords them an expanded capability for maritime domain mission sets.

Intelligence Processing, Exploitation, and Dissemination

NAGSF has already achieved an initial PED capability. With the arrival of the full system and the integration of data from Alliance nations, the Joint and federated ISR output will become more robust and comprehensive to meet the needs of the Alliance. The PED Centre will become a focal point for providing senior military and political leaders with critical intelligence to inform their decisions. The NAGSF Operations Centre (NAOC) will be the hub of both air operations and federated PED activity. This centre also includes the ability to synchronize fixed and expeditionary PED and Command and Control capabilities.

- **Fixed:** An imagery exploitation capability that provides single-source and fused intelligence products from a fixed location at the Main Operating Base in Sigonella. The collection, data storage, and sharing mechanisms employed by NAGSF will enhance NATO nations' access to intelligence data not otherwise available. This adds to an operational approach that expands on nationally gathered intelligence, which will, in turn, increase the Alliance's readiness. Overall, this is a key tool that enables a collective defence effort by furthering the production and sharing of Joint ISR data throughout NATO and its member nations.

- **Expeditionary:** Deployable ground assets consisting of several mobile systems comprised of imagery exploitation and communications capabilities. This capability is scalable, with assets equipped to support tactical to theatre-level operations. This expeditionary capability provides ground commanders near-real-time intelligence and a node that enables ground-level situational awareness required for a readied posture.

Training and Personnel

NAGSF is composed of experts from 18 different national forces with significant experience operating and maintaining high-altitude Remotely Piloted Aircraft (RPAs).

'… [NAGSF] demonstrates that NATO Allies are committed to modernizing the Alliance and investing to deliver key cutting-edge capabilities to the benefit of our shared security.'

Many have flown RPAs in European airspace with their national militaries. These motivated, handpicked high altitude experts have been placed in key operations and maintenance billets to ensure a successful and rapid operationalization of this capability.

Long-term, NAGSF plans to grow its training cadre into a full-fledged Training Centre capable of significant student throughput to provide an array of world-class Joint ISR courses to all NATO nations. The ultimate vision for the NAGSF Training Centre is to become a nexus of NATO's ISR and PED knowledge and experience. The Training Centre will take students, regardless of their ties to NAGSF, and turn them into trained and qualified ISR experts to enhance both NAGSF and their home nations' JISR effectiveness.

Additionally, a small group of NAGSF personnel are present at SHAPE and Allied Air Command (AIRCOM) Headquarters. These liaison personnel assist in furthering NATO Joint ISR Policy, RPA Integration, and participation in NATO interoperability trials, positively influencing Alliance-wide training objectives.

Mission Sets

While NAGSF is still in its formative stages of organic collection and sortie generation, the majority of its effort will focus on three main mission sets:

- **Indications and Warnings (I&W):** Providing the Alliance key I&W is likely to be NAGSF's most important mission set for NATO. The aircrafts' sensors and supreme endurance allow for wide-area collection and persistent surveillance, enabling NAGSF to monitor and identify changes in posture and asset locations to increase the ground and maritime picture situational awareness for senior political and military decision-makers.

- **Crisis Response (CR):** CR is an equally fitting mission set for NAGSF, to include broad area target surveillance to detect enemy forces manoeuvring across the battlefield. Utilizing the sensor's movement tracking capabilities, NAGSF can monitor large areas and relay actionable call-outs in real-time to other Alliance assets that are capable of visually identifying unknown or hostile movers.

- **Humanitarian Assistance and Disaster Relief (HA/DR):** HA/DR is a less obvious, but no less important, mission for NAGSF. A combination of overhead NAGSF aircraft and deployed ground systems can provide on-scene disaster relief teams with real-time information concerning the situation on the ground. SAR imagery can provide a damage assessment of

buildings and critical infrastructure, while movement indications can identify traffic patterns, road blockages, and isolated victims.

Programme Timeline and Goals

The acquisition of a programme of this scale is a first in NATO's 70-year history and provides NATO with leading-edge strategic technology. The NAGSF programme has been in development for nearly seven years and is now transitioning from the acquisition to the operational phase, all because of the tremendous efforts of multiple stakeholders. Countless hours of work and millions of pages of documents have been written, reviewed, revised, and approved by organizations spanning nearly the whole of NATO. This has been a massive team effort between several contracting companies, multiple NATO committees, the Italian Ministry of Defence, the Italian Directorate of Air Armaments and Airworthiness (DAAA), and the 15 procuring NATO nations. A great example of the groundbreaking work accomplished through this acquisition is DAAA awarding the first-ever Military Type Certificate (MTC) in the history of aviation to a high altitude unmanned aerial system.

Two of the five RQ-4D aircraft are at Sigonella, with the other three anticipated to arrive shortly. In the meantime, NAGSF will work to become fully operational by flying sorties in support of SACEUR and NATO. NAGSF anticipates achieving full operational capability by 2022.

Conclusion

The Alliance provides an umbrella of protection for over one billion people and represents half of the world's economic and military might. NATO continues to evolve with the changing threats and geopolitical landscape, and, by acquiring NAGSF, responded with the biggest reinforcement to our collective defence and deterrence capabilities in decades. As Secretary General Jens Stoltenberg recently stated, '… [NAGSF] demonstrates that NATO Allies are committed to modernizing the Alliance and investing to deliver key cutting-edge capabilities to the benefit of our shared security.'*

NAGSF is the physical manifestation of NATO's collective defence strategy and demonstrates the Alliance's relevance and strength against our global competitors. NATO's first and only high altitude ISR programme is a state-of-the-art capability that brings an unprecedented leap in the Alliance's ability to collect, process, and disseminate intelligence amongst its members. It provides a multi-domain and integrated ISR capability absent in most nations across the globe, and is a capability that Alliance nations can call upon in times of national emergency. A peaceful Europe is a prosperous Europe; a prosperous Europe is a secure Europe – NAGSF is a reflection of NATO's commitment to this concept. ●

*https://www.nato.int/cps/en/natohq/news_171171.htm

Major General Phillip Stewart

is the Commander for the NATO Alliance Ground Surveillance Force, stationed at the Italian Air Force Base Sigonella. Major General Stewart was commissioned in 1992 and has commanded at multiple levels in the US Air Force, including twice in combat, first as Commander of the 362nd Expeditionary Reconnaissance Squadron at Balad Air Base, Iraq, and most recently as Commanding General of NATO Train Advise Assist Command-Air and 438th Air Expeditionary Wing Commander in Kabul, Afghanistan. He also served as the Wing Commander of the US Air Force's 9th Reconnaissance Wing. Major General Stewart has served as an instructor and evaluator pilot in multiple aircraft and holds the rating of command pilot.

Space Situational Awareness

Together We Stand, Divided We Fall

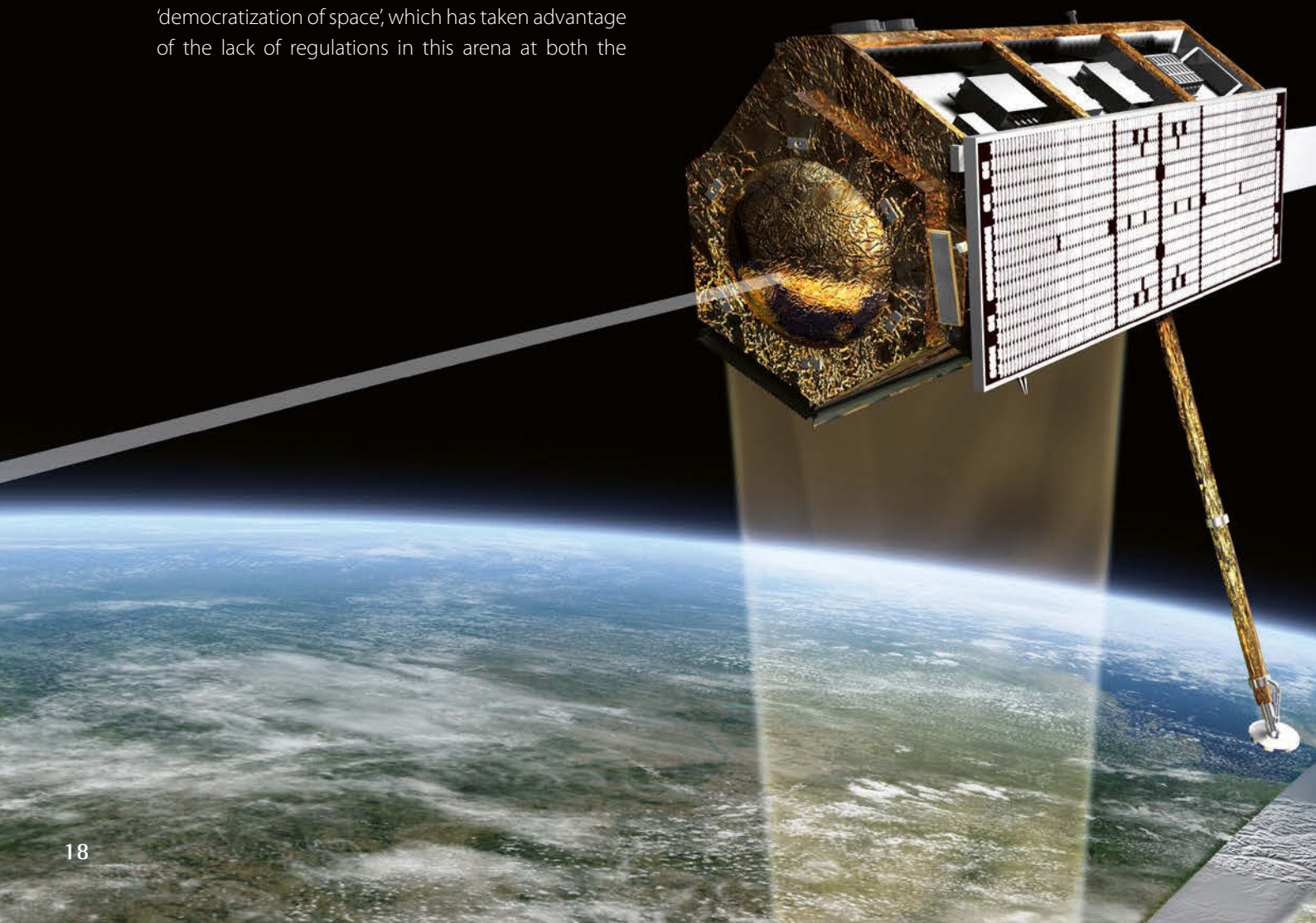
By Major General Juan P. Sánchez de Lara, SP AF, Commander in Chief
Canary Islands Air Command

Space as an Operational Domain

Space operations have arrived to stay. The later we realize it, the later we will be organized, equipped, trained and therefore ready to respond to any incident affecting the access to our National space services or capabilities. These services or capabilities, many of them dual-use (civilian/military), are very expensive and are considered as both strategic assets and as a 'question of sovereignty'.

However, the threats to our national strategic space assets are already there. Being a satellite operator is becoming a risky business because of the so-called 'democratization of space', which has taken advantage of the lack of regulations in this arena at both the international and national levels. This is making space more accessible to public and private users, but that increased access comes at a price.

Traditionally, space debris is considered as a risk to space assets. Since the launch of Sputnik 1 until today, 8,400 tons of space objects of many different sizes have found their way into orbit around the Earth[1]; with speeds up to approximately 7.8 km/s (28,000 km/h). One can imagine the consequences of an impact of any object, no matter its size, at these speeds.



The number of active satellites orbiting the Earth (currently estimated at around 2,000)[2] will significantly increase with the launches of new mega-constellations within the next ten years. Most of these new satellites are planned to be launched in the Low Earth Orbit (LEO), which is already the most crowded and polluted orbit.

Consequently, the risk of collisions will increase, and the risk of accidental collision will be compounded by the knowledge that a satellite can be manoeuvred to impact another targeted satellite. These risks are becoming security threats, and the number of passive control measures, such as collision avoidance manoeuvres, will surely intensify.

However, collisions in space are not only what nations should focus their efforts on avoiding. Space is becoming more contested and disputed, and this type of competition brings into this new theatre of operations intentional threats to different national capabilities, turning them into easy targets and, therefore, changing the nature of space, theoretically used for peaceful means, as expressed in the United Nations (UN) Outer Space Treaty.

Recent documented examples of incidents with satellites, specifically constructed to harass the operation of other satellites, include the incident between the Russian Louch-Olymp satellite and the Franco/Italian Athena-Fidus, in 2017[3] and the use of anti-satellite armament, as demonstrated by China in 2007 and by India in 2019, both of which produced a vast increase in the number of space debris. There are other threats, such as cyberattacks, the use of directed energy weapons against sensors or platforms, kinetic capture systems and jamming or spoofing that are also becoming of increasing concern.

These threats can be used by near-peer or peer states, as well as by terrorist or like-minded groups, in events or actions not necessarily associated to warlike conflicts, even in day to day activities.

The Spanish Air Force Approach to Space Defence and Security

Spain, like many other countries, has reason to enter this new theatre of operations. We care about our space assets (military, civilian, dual) and we want to play a bigger role in defending our interests and freedom of access to our space assets. Being a 'question of sovereignty', our objective is to reach and maintain a certain level of self-sufficiency to guarantee our strategic autonomy.

And of course, the role of the Spanish Air Force in protecting our interests in space has been already delineated, as in other countries.

Spanish Air Force doctrine considers operations in the third dimension (Air and Space), integrated, as a continuum, from the ground, through the air until outer space. This is not just because of historical and traditional reasons, being the space-oriented service from its origin and having already some 'aerospace' units (Intelligence, Surveillance and Reconnaissance, Training and Education, Medical, Command and Control), but because operations in outer space, up until Geostationary Earth Orbit (GEO), are interrelated with the use of airspace. This includes missile defence, anti-satellite operations, hypersonic missile defence, stratospheric platforms and space traffic control.

The recently released National Aerospace Security Strategy (April 2019), signed by the Spanish Prime Minister, considers both domains in a single strategic domain requiring a unified action.

In 2018, the Chief of Defence (CHOD) assigned the Spanish Air Force with the standing mission of 'Space Surveillance'. This is what Spain is currently doing; but building this capability now has an urgent requirement. The origin, in Spain, of the space capability is characteristic of its dual vocation, (civil and military), as in most of the countries.

The Space Situational Awareness (SSA) programme, which started as a European Space Agency (ESA) programme lead by Spain, is the ESAs initiative designed to support Europe's independent space access and utilization through the timely and accurate delivery of information regarding the space environment and, particularly, hazards to both in orbit and ground infrastructure. One of the segments of the SSA programme is the Space Surveillance and Tracking (SST) segment, built to track active and inactive satellites and space debris.

In 2015, five European Member States (France, Germany, Italy, United Kingdom and Spain) formed the SST Consortium to implement the SST Support Framework, (which had been adopted by a Decision of the European Parliament and Council), and develop a European SST capability. Three other countries (Portugal, Poland and Romania) also joined the Consortium in 2018. The services to provide include collision avoidance and tracking of the fragmentation and re-entries events.

The Spanish Space Surveillance and Tracking Programme (S3T) was created in 2015 and is managed by the Centre for Industrial Technological Development (CDTI). In 2016, the Spanish Space Surveillance Operations Centre (S3TOC) was commissioned, at the Torrejón Air Force Base facilities, under an agreement between CDTI and the Ministry of Defence.

It should be noted that the S3TOC is a civil agency providing the services that the European SST Consortium is entrusting it with, which is currently just collision prevention.

Therefore, a need now exists to create an SSA capability to be led and managed purely by military personnel and for military purposes. This must be fully coordinated with S3TOC to minimize duplication and maximize synergies.

Chief of the Air Force Directive

The Chief of the Air Force Directive 06/18 tasks the 'Implementation of space surveillance capability within the Spanish Air Force' to comply with different CHOD operational planning documents that assigned the Air Force with the surveillance and awareness of the Outer Space, as a permanent mission, to protect the Spanish interests.

The Directive is, in a way, a flight plan that will show the way forward for the Space Defence capability development.

The creation of a new Air Force unit, the Space Surveillance Operations Centre (COVE[4], in Spanish), whose mission, in collaboration with the S3TOC, will be to maintain SSA, is the most relevant aspect of the Directive, supporting access to space capabilities.

Building such capability is not an easy task, and to make it happen we are considering all capability development areas in the DOTMLPFI: (Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities and Interoperability).

Space Airmen at the Centre of Gravity

There are challenges regarding how we identify, educate and train personnel, like there are in any other country. However, we are developing the right measures to implement a career for space airmen, starting in the Air Force Academy, specialized, not in the support of space for military operations, but for space operations themselves. The goal is to provide control of the Air & Space, to be able to operate in the outer space, to integrate space in Multi-domain Operations, and to integrate them into organic and operational structures; specific (Air Force), joint (Joint Operations HQs) and multinational (NATO, EU).

In the meantime, we are taking an aggressive approach training our COVE personnel in their mission, alone or together with our partner/allied Space Operations Centres, in order to build the essential interoperability needed to succeed in providing security and defence to our space capabilities.

It is evident that we cannot perform this mission alone; and, during this process, we have realized also that no other country can do this alone either. Our doctrine, our organization, our personnel, including our leaders, our education and training, our sensors, our software, are useless unless they are interoperable.

A single failure in space could mean a global failure and possibly a disaster for humanity. Or at least it would imply the loss of very expensive capabilities and highly-needed services.

Can we afford such failures?

Stronger Together

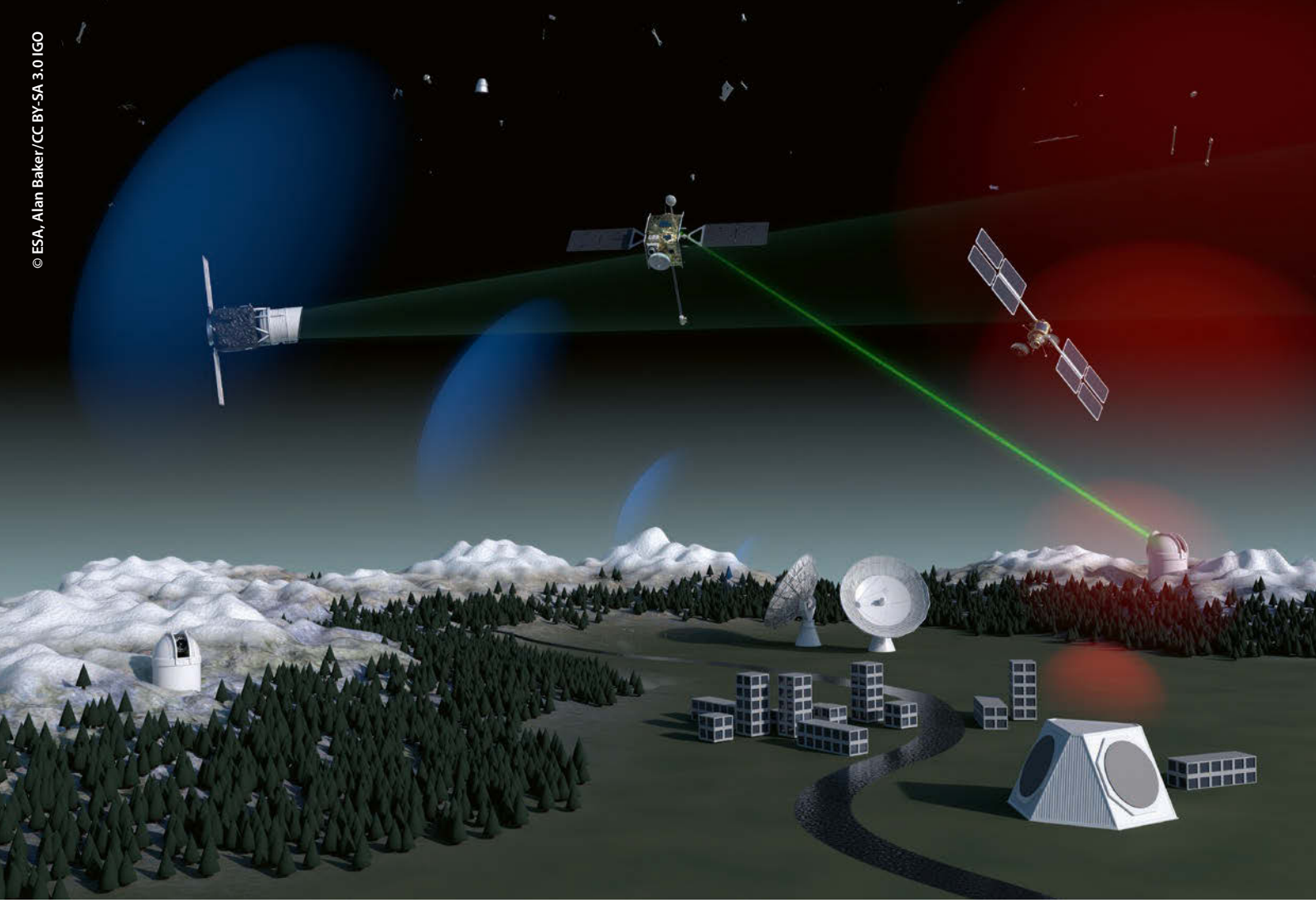
For that to happen, to be stronger, every nation has to realize that if we want to win in space, we have also something to give up.

Space is a not only a global common, it is a shared common.

We must not forget that in this type of operations we never walk alone, and that if a conflict starts in space, everybody loses.

So, how do nations prevent that from happening?

Rules have to be established concerning behaviour in space, as we have for airspace; and have communication lines open and established to minimize the opportunity for a miscalculation or uncertainty.



There is no greater confidence-building measure than sharing the critical and timely information needed for success on the battlefield. And space will become a battlefield. Maybe it already is.

Integration is the Way to Go

NATO, having declared Space as an operational domain, is taking the initial steps to increase the cooperation and coordination of all Allies and the space capabilities they own. This is probably the correct approach, taking into account the interests (and prerogative) of Nations to maintain operational command and control of their assets, for sovereign reasons.

Integration, more than coordination, will provide the best standards to improve the safety, stability and sustainability of space. Now, the challenge is how that level of integration is implemented.

It is up to the willingness of the Nations to allow the soon-to-be-created NATO Space Operations Centre to be the answer to the solution. We are talking about providing security to our space assets and the support they are providing.

In December 1955 the NATO Military Committee approved the implementation of the NATO Air Defence Ground Environment (NADGE). The NATO nations agreed to place their Command and Control systems, radar installations, Surface-to-Air Missile units and Quick Reaction Alert aircraft under the NATO Commanders. In 1972 NADGE became NATINADS (NATO Integrated Air Defence System) and with the advent of the Missile Defence task, it turned into NATINAMDS.

The keyword of this long acronym is neither Air nor Missile, not even Defence. It is Integrated. This is the value that NATO, being the sum of efforts of 29 countries, is adding to the individual efforts. Having transferred the authority of our national assets to a NATO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Commander was not an easy decision, and required a lot of trust in the 'NATO system', the NATO way of performing this essential mission, once again agreed by nations. It has become a history of success, once again because trust has been built between Nations, and under the leadership of an expert and mission-oriented organization.

So, why not doing the same with Space Defence? The Missile Defence part of NATINAMDS took some time to be agreed upon by nations, nevertheless it was implemented. NATO nations should not be reluctant to an integration process of Space Defence that has been demonstrated successful in the Air & Missile Domain. Why not a NATO Integrated Air/Space and Missile System (NATINASMDS)? Maybe it is a question of time, a question of trust, or an imperative …

Conclusion

Every day that passes without the best integration effort by all nations (not only NATO nations), there is an increasing danger of risks, and more importantly, threats becoming a reality. These might not only temporarily affect the provision of some services, but, worse of all, could provoke a space disaster, (Kessler effect[5]), rendering space activities impossible for generations.

Think about our collective preparedness, our collective readiness to provide security in space, to guarantee freedom of access to space services and capabilities to our countries.

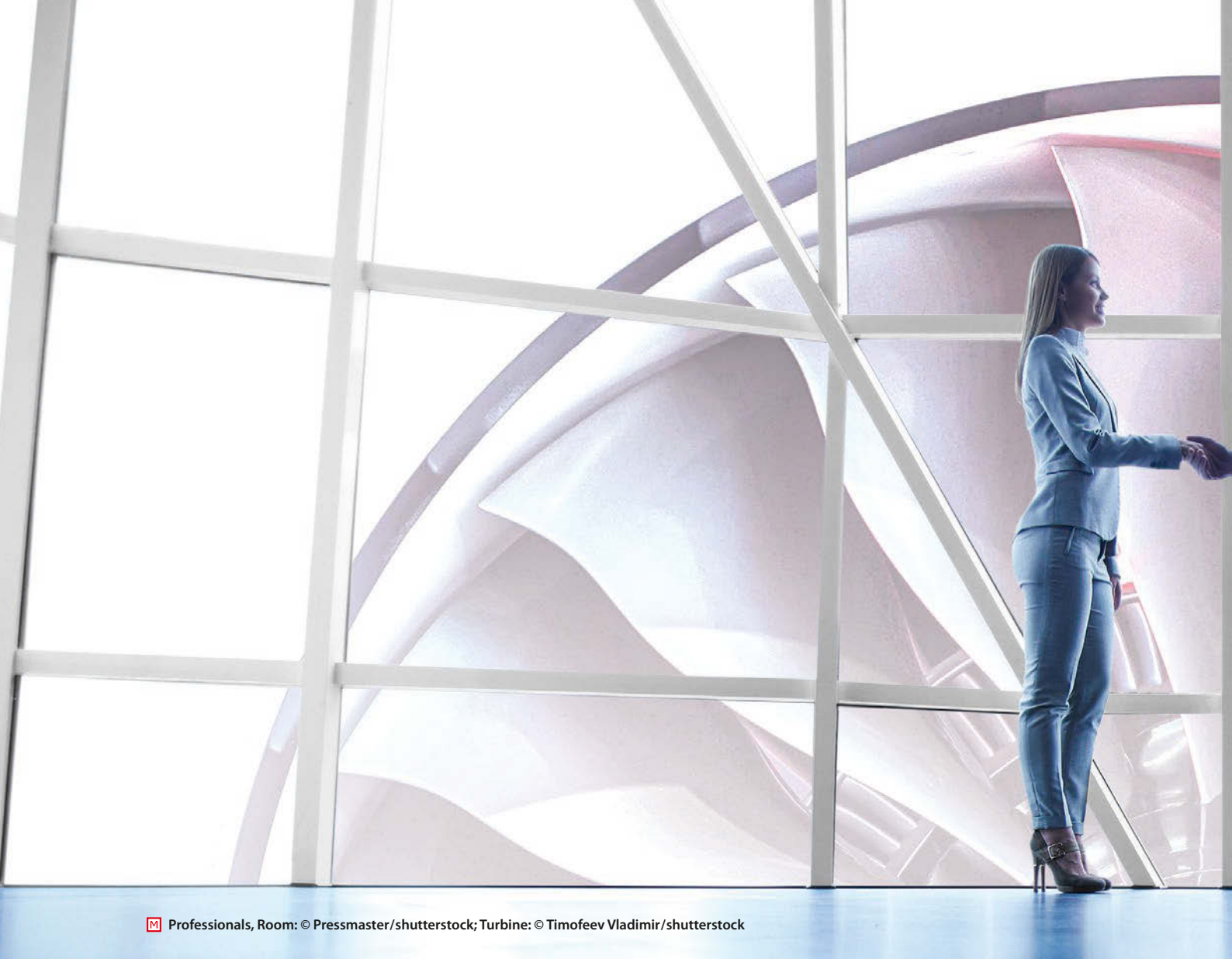
As the French Ministry of Defence said recently in a speech[6], 'We are in danger, our communications, our military operations as well as our daily lives are in danger if WE DO NOT REACT …'

'… TOGETHER, NOT DIVIDED', I would add. ●

1. https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers
2. cnbc.com/2020/02/17/space-junk-raise-concerns-as-more-and-more-satellites-are-launched.html
3. https://www.lemonde.fr/international/article/2018/09/07/paris-revele-une-tentative-d-espionnage-russe-sur-un-satellite-franco-italien-en-2017_5351908_3210.html
4. COVE stands for Centro de Operaciones de Vigilancia Espacial.
5. NASA space debris expert Don Kessler observed that, once past a certain critical mass, the total amount of space debris will keep on increasing: collisions give rise to more debris and lead to more collisions, in a chain reaction.
6. https://satelliteobservation.net/2019/07/27/frances-new-space-defense-strategy/

Major General Juan P. Sánchez de Lara

commissioned through the Spanish Air Force Academy in 1985, he became a fighter pilot, flying a total of 3,500 hours in Mirage F1 (Albacete AFB), Northrop F.5 (Moron AFB and AF Fighter Weapons School at Talavera AFB) and Casa 101 (AF Academy). He was posted to SHAPE (Mons) J3 as Air Ops and Targeting Officer (2007–2010). He also has been deployed to operations in Bosnia-Herzegovina (1997–1998) and in Djibouti (2011). As a Colonel he was designated Director of the AF Officers Academy. In December 2017 he was promoted to Brigadier General and designated Spanish AF Air Staff Plans & Policy Division Head. In June 2020 he was promoted to Major General and appointed as Commander in Chief Canary Islands Air Command.



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The Case of PEGASUS

The Development of Competences for Space Power from a University Perspective

By Prof Gustavo Alonso, Universidad Politécnica de Madrid, Chairman of PEGASUS

Introduction

The space sector is strategic. It offers nations science and technology, industrial power, economic return and military power. Space is becoming more accessible. More countries now have the opportunity to use more or less sophisticated space assets and it is becoming more competitive with the involvement of more private organizations. Overall, space is providing new opportunities, such as new applications and services (5th generation wireless communication (5G), Internet of Things (IoT) and space tourism) or in situ resource exploitation.

PEGASUS Industry Alliance: Increase cooperation between partners and industry.

Society depends more and more on satellites especially for communications and navigation, but also for meteorological forecasts and many other applications. Many of our daily activities rely heavily on space assets. Those services are taken for granted and have become utilities, but those assets and services need to be protected. Therefore, space warfare will play an increasingly important role in the future. This reliance on satellites makes them primary targets in order to disable enemy capabilities. The possibility to destroy or disable spacecraft is not excessively complicated because both military and civil space assets are essentially vulnerable.

War can be taken to space, with different combat scenarios: Space to Ground, Space to Space or Ground to Space.[1] Also from this perspective, access to space is getting easier and cheaper, thanks partly to the development of increasingly capable smaller satellites, which in constellations can generate capabilities comparable to a standard satellite. This, in turn, will provide to any nation an observation capability from space. Consequently, space is becoming increasingly militarized.

On the military side, as well as for commercial or civilian satellites, congestion in space is a major issue due to the increasing risk of collision and the problems associated with the proliferation of space debris.

International Cooperation in Space

The body responsible for international space law is the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS). Among the International

treaties negotiated in the COPUOS, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the 'Outer Space Treaty', 1967) is the most widely adopted treaty, with 104 parties, and it is the foundation of international space law. The guiding principles are that space exploration should be a peaceful initiative and that all nations should have free access to space.

Despite this and other treaties, there are open challenges today with respect to space law[2]:

- Vertical extent of sovereign airspace.
- Liabilities linked to space debris: debris (accidentally or deliberately created) will continue to increase. If debris causes damage or loss of life down on Earth, the liability is on the launching State. But what if debris causes damage in space?
- New technologies and new business models: the Outer Space Treaty says no nation may appropriate territory anywhere in space, but what about individuals and corporations?
- Militarization of space.
- Outer space: issues like exploitation of natural resources or territorial sovereignty in other bodies is becoming more important as plans to explore and exploit outer space accelerate.

On the other hand, international cooperation is the means to make ambitious space scientific and exploration missions feasible. International cooperation shows today a variable geometry. However, we can identify two sides in this network of alliances: the group of agencies around the United States of America (USA): Europe, Canada, Japan and Russia; and the network being developed by China and their 'Space Silk Road'[3]. At the same time, some space powers like India are not yet aligned.

Beyond scientific objectives, there is a clear aim in these missions to explore the possibilities of obtaining and using resources from outer space. It is clear that there are strong economic interests that need to be protected/promoted/made reachable by a Space Force. It appears inevitable that the USA and China will compete for supremacy in space, but it is not yet clear what will be the role of other nations. Space is a long-term project; alliances need to be stable and the natural prolongation of geopolitical alliances need to be maintained. In addition, increasingly easier and cheaper access to space and critical new technologies multiplies the number of potential aggressors within space like terrorist groups or failed states.

Development of New Competences

In this context, any Space Power, integrated into their corresponding Ministry of Defence (MoD) or Department of Defense (DoD) will experience an evolution in the framework of its relationships with other stakeholders. We can mention for instance:

- Public-private cooperation for technology development and even for operations. The National Aeronautics and Space Administration Commercial Lunar Payload Service (NASA CLPS) programme allows contracts with American companies for payload integration and operations, launching from Earth (Space Exploration Technologies – SpaceX) and also landing on the surface of the Moon (Blue Origin).
- Increased coordination with space agencies for elements such as 'Space Situational Awareness' or 'Planetary Protection'.
- Cooperation with Industry: dual technologies to optimize the Resource and Development (R&D) resources and expenditures, spin-offs or side-utilizations of technologies developed by the industry with different purposes.
- Cooperation with Universities in R&D and training as it is being extensively done by the Industry. One example in Europe would be the European Consortium for Advanced Training in Aerospace (ECATA), with the participation of leading Academic Institutions as well as the leading Aerospace Industries with the purpose of designing and delivering a yearly course on management of multinational aerospace projects for highly qualified young engineers.

Space Powers, in order to accomplish their assigned missions, need people developing a variety of different functions. People are changing very rapidly, for

example, training and educational institutions are finding newer generations of digital natives with a completely different relationship with machines, technology and especially data handling. The generational gap between our population is increasing at an accelerated pace.

New training methodologies need to be applied, especially in education. Innovation (Project Based Learning) together with new training formats related to wiki, Massive Open Online Courses (MOOC) and Small Private Online Courses (SPOC) are all in development. But above all, the correspondence between the new challenges (scenarios, missions, technologies) and the new people are the new competencies that are needed.

The aerospace industry and academia have been investigating the new competences needed by professionals, mainly but not exclusively engineers[4]. A similar approach could also be applied by the space forces to their professionals. The concept of the T-shaped professional could be of interest, which is a metaphor for the depth and breadth that an individual has in their competencies. A 'T-shaped' engineer is an ideal candidate to be a cross-functional team member.

- Has deep knowledge in at least one area and can be a problem solver in it.
- Understands many other areas and their complexities and knows how to communicate clearly in that area.
- Possesses boundary-crossing competencies mainly related to the ability to work efficiently in a team. For example, communication, critical thinking or processes and engineering practices.

In their Strategic Research and Innovation Agenda (SRIA)[5], the Advisory Council for Advance Research in Europe (ACARE) highlights the role of the T-shaped professional in the '… understanding of the balance between multi-disciplinary and in-depth knowledge …' and it continues, 'We need to ensure engineers are capable of integrating interdisciplinary competencies of a technological, human and social nature as one of the enablers to achieve the aviation goals of 2050 in Europe.'

In the document 'The Future of Jobs. Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution'[6], the World Economic Forum identifies the required top skills for the new professionals:

- Complex Problem Solving
- Critical Thinking
- Creativity
- People Management
- Coordinating with Others
- Emotional Intelligence
- Judgment and Decision-Making
- Service Orientation
- Negotiation
- Cognitive Flexibility

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Space is too big for just one nation; consequently international cooperation is essential.

Country	Institution
	• Politecnico di Milano • Politecnico di Torino • Università di Bologna • Università degli Studi di Napoli • Università degli Studi di Pisa • Università degli Studi di Roma
	• Ecole-air de Salon de Provence • ENAC Toulouse • ENSMA Poitiers • ISAE Toulouse • ESTACA – Paris
	• TU Delft
	• UPM/ETSIA Madrid • US/ESI Sevilla • UPV/ETSID Valencia
	• IST Lisboa
	• University of Zilina
	• RWTH Aachen • TU Berlin • TU Braunschweig • Universität Stuttgart • TU Dresden
	• Cranfield University • University of Bristol • University of Glasgow
	• KTH Stockholm
	• CVUT Prague
	• Politechnika Warszawska

Members of PEGASUS.

PEGASUS: A Model for European Recognized Skill Profile

Founded in 1998, PEGASUS aims to offer itself as the European portal for higher education services in aerospace, being recognized as the most efficient channel to get university inputs at the integrated European Union (EU) level. PEGASUS is open to all EU institutions providing a sufficiently qualified education in aerospace engineering. Today 28 Institutions from eleven European countries are represented. PEGASUS partners have a reputation for high-quality research and a quality recognition in education and research.

The network's goals are the following[7]:

- Contribute to the development of a quality system for the European higher education in Aerospace Engineering.
- Improve educational process and curricula to specifically serve the needs of the aerospace industry.
- Cooperate with other groups and networks to fulfil the EU policy lines in higher education.
- Increase cooperation between partners and industry (PEGASUS Industry Alliance) as well as national and European research agencies (PEGASUS Research Alliance).
- Contribute to attract non-European students and engineers through competitive curricula and continuing educational services.

To develop its activities, the PEGASUS Network also establishes Working Groups (Academic Aerospace Research, Accreditation and Women in Aerospace Engineering), which are non-permanent bodies and modified according to actual needs. Particularly relevant is the Working Group on 'Aerospace Education and Quality', aiming at developing a roadmap for quality assurance in aerospace education and monitoring the PEGASUS educational offer in Aerospace Engineering, editing and updating the PEGASUS Course Catalogue.

PEGASUS, as the only European network of excellence in Aerospace Engineering education, has established an entity for developing a quality/excellence label, Promoting Excellence & Recognition Seal of European Aerospace Universities (PERSEUS). Led by PEGASUS,

the EC H2020[8] financed project PERSEUS and has identified a possible roadmap for the definition of a European quality label for aerospace-related higher-education degrees, involving a great portion of the European stakeholders in aerospace: Universities, research centres, industries (both small and large) networks and associations, and accreditation agencies[9].

The core concept established by the project is that it is possible to establish a sector-specific quality system, which can complement the existing national or European accreditation systems, providing added value to the internal and/or external quality assurance processes that are in place in most EU Universities.

The proposed method relies on the definition of a set of core skills and abilities both technical and personal, specific for the aerospace domain and expressed in the form of learning outcomes. These skills are identified by all the stakeholders of the higher education process. Once the sector-specific skills are defined, these form the basis for the evaluation of the fitness-for-purpose of the curricula offered at the EU Universities. Each University will be asked to identify the level of achievement of the identified skills, whereas the employers have been asked to rank the importance of each skill for their specific needs. A comparison of the levels offered by the curricula and the needs of the employers would define the employability of the graduates, hence the sector-specific quality of the curricula.

Conclusions

The future is challenging, as it has always been. The environment is changing, as it has always done. The Space Force must prepare for and to anticipate those changes in future scenarios, missions, technologies, vehicles, business models, people, and competences. Space is too big for just one nation; consequently international cooperation is essential. Space power needs to be prepared for various forms of confrontation and different types of threats from different types of contenders. Therefore, new competences have to be trained and acquired. ●

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2. Ibid.
3. https://www.beltroad-initiative.com/space-silk-road/
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5. Advisory Council for Advance Research in Europe (ACARE), Strategic Research and Innovation Agenda (SRIA).
6. World Economic Forum, The Future of Jobs Report, 2018.
7. www.pegasus-europe.org
8. European Commission Horizon 2020 programme.
9. PERSEUS-D1.5 – Final Report, EC Grant Agreement Number: 640211.

Professor Gustavo Alonso

received a Master in aerospace engineering from Universidad Politécnica de Madrid (UPM) in 1990, an MBA from IESE in 1998 and a PhD in aerospace engineering from UPM in 2005. He is currently Professor at the School of Aerospace Engineering of UPM. He is the Programme Director of the microsatellite UPMSat-2. He is a Visiting Professor at several Universities in Europe, America and Asia, and a member of the Physical Sciences Working Group of the European Space Agency (ESA). He is currently Chairman of PEGASUS and member of the Standing Council of BRAIA (Belt and Road Aerospace Innovation Alliance). Before joining the University in 2005, he was working for ESA, Airbus and different engineering companies for 15 years.

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State's Right to Self-Defence in Outer Space

A New Challenge for NATO's Deterrence

By Dr Anne-Sophie Martin, Department of Political Sciences, Sapienza University of Rome

Introduction

NATO clearly identified outer space as the fifth military domain beside air, land, sea and cyberspace on November 2019, in response to expanding issues over protecting space assets from hostile intentions such as interference.[1] As mentioned by the NATO Secretary General, Jens Stoltenberg, during a press conference in Brussels 'this can allow NATO planners to make a request for allies to provide capabilities and services, such as satellite communications and data imagery'.[2]

There are about 2,000 satellites in the Earth's orbit, at least half of them are owned and operated by NATO member States.[3] Still, the Alliance does not possess its own space assets, and depends on the technologies of its members. This is a reality that space is becoming more and more important for military operations and missions. However, the Secretary General assured that NATO's approach '… will remain defensive and fully in line with international law. NATO has no intention to put weapons in space. But we need to ensure our missions and operations have the right support.'[4]

These words illustrate the growing significance of outer space for the Alliance. Space is part of our daily life on Earth making space assets an integral part of national and international infrastructure. Moreover, space assets represent crucial elements to support military or humanitarian operations on Earth through remote sensing data, navigation, and telecommunications. Outer space can be used for peaceful purposes, but also in an aggressive way. As of now, the dependence on space assets is the reason why they are an attractive target to adversaries. Hence, space is becoming an essential tool for the Alliance's deterrence and defence.[5] It is crucial for NATO member countries that during the missions and operations they will undertake, they have the right support. Today, without satellites, modern warfare can no longer work. More and more countries are therefore developing new technologies such as Anti-Satellite (ASAT) weapons[6] or cyberattacks to damage enemy satellites in case of 'aggressive' behaviour against space assets. Espionage should also be taken into account, just as in the case when a Russian satellite came close to the French-Italian satellite 'Athena-Fidus' used for military communications in October 2017.[7]

Another more recent example concerns a Russian inspector satellite which shifted its position in orbit to get closer to a United States (US) spy satellite.[8] New space applications such as on-orbit servicing vehicles, due to their dual-use nature, might also represent a menace as they may be used in a hostile way against the space asset serviced.

The Legal Perspective of Outer Space

From a legal perspective, two substantial articles have to be stated when discussing the military use of outer space. First, Article III of the Outer Space Treaty (OST)[9] stipulates that States shall carry on space activities in accordance with international law, including the Charter of the United Nations (UN). Then, Article IV paragraph 1 of the OST does not provide a complete demilitarization of outer space, but a denuclearization regime. In fact, States are unrestricted to deploy in outer space any type of military satellites and to use outer space for conventional weapons. Its paragraph 2 concerns the use of the Moon and other celestial bodies and it introduces full demilitarization of the Moon and other celestial bodies. Article IV denotes some ambiguities in the sense that it prohibits the use or placement in space of 'nuclear weapons or any other kinds of weapons of mass destruction' but it does not address the issue of conventional weapons. In this context, some activities carried out by States reveal the limits of Article IV such as the use of ASAT missiles[10] by China, the US and more recently India.

States have the challenge to balance their commitment to international laws and the UN space treaties with protecting their space assets and interests in space activities from hostile action.

Linking Space Assets with States

In case of aggressive or hostile action against a space asset, the right of self-defence in outer space arises.[11] Self-defence is a notion of international law linked to a State's territory.[12] Indeed, it refers to the right of a State to respond to armed attacks against its territory.[13] In the first instance, one can argue that because outer

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space is an area beyond national jurisdiction, self-defence is not permitted in this environment. However, practice demonstrates that the right of self-defence is also in relation to the use of force against facilities and objects under the jurisdiction of a State, not just its physical territories.[14] In this context, it is important to underscore the fact that an object launched into outer space, such as a satellite, must be registered by the launching State on an appropriate registry which it shall maintain.[15] Thus, registration shapes a link between the registering State and the object registered that enables State to exercise its jurisdiction over its asset. Hence, States can legally conduct action in self-defence to respond to attacks against space objects that they have registered.[16] One can highlight the fact that the right of self-defence in space is similar to the protection of vessels on the high seas or aircraft flying in international air spaces.[17]

Satellites can be 'attacked' using kinetic means, for instance ASAT, laser, microsatellites used as 'explosive devices', or non-kinetic means such as cyberattack, jamming, or interference. Hence, 'attacking' a space asset can reduce its functionality or destroy it, and it can create a strategic military advantage for the adversaries in case of conflict in outer space. These actions may represent an armed attack[18] leading to the activation of the right of self-defence.

Given the crucial importance that space assets represent for military, social and economic systems, States seek to protect their assets against menaces that could damage or destroy them.[19] States are placing the protection of space assets at the core of their defensive strategies and declaring their intention to act in self-defence in space if needed.[20] In 2019 France presented a national space strategy with the establishment of a 'Space Command'.[21] In addition, the United States recently established the US Space Force as the sixth military branch.[22]

Jus Ad Bellum in Space

Nevertheless, the exercise of the right of self-defence in outer space represents a grey area of international law.[23] First, States have to consider Article 2.4 of the UN Charter which prohibits the use of force in international relations. However, the UN Charter foresees two main exceptions to the prohibition on the use of force in international relations: (i) the use of force authorized by the Security Council under Chapter VII of the Charter; (ii) the individual or collective right of self-defence pursuant to Article 51 of the UN Charter. Both provisions are based on the *jus ad bellum* that is the circumstances under which it is lawful to employ military force.[24]

As mentioned, 'jurisdiction' over these objects is considered to correspond to 'sovereignty', and so the right of a State to defend objects under its sovereignty on Earth coherently extends to outer space. Thus, as long as states do not interfere in a hostile manner with the space assets of other states (thus violating of Article 2 (4) of the UN Charter) and do not station weapons of mass destruction or nuclear weapons in space, their right to act in self-defence in outer space pursuant to customary law and Article 51 of the UN Charter cannot be denied.

Some questions must be emphasized: do offensive or defensive actions in space warfare cause re-alignments to allied treaties? In other words, if a NATO Member State is attacked in space, does that automatically mean that NATO countries will come to its defence? According to Articles 5 and 6 of the North Atlantic Treaty, in case of an armed attack against one or more NATO Member States, it shall be considered as an attack against them all and consequently, the right of individual or collective self-defence shall be activated and shall assist the Party(ies). Here, it is admitted that the State jurisdiction is extended to its space assets, and in case of armed attack in space against one or several NATO Member States, the others may be able to support them.

Concluding Remarks

These issues deserve new rules and much more attention from the international community. There is an imperative need to revisit the existing framework of international laws pertaining to space and State behaviour. It is necessary to reconsider the area of intervention, as outer space is a new 'military domain'. In June, NATO defence ministers first announced the creation of a space strategy[25], intending to protect satellites that are crucial for communication, navigation, early warning systems for rocket launches, and status reports in conflict zones. The North Atlantic Alliance could implement a policy similar on what already exists in the field of cyberspace operations. Indeed, NATO outlined that a cyberattack can, under certain circumstances, be considered a reason for activating Article 5 of the North Atlantic Treaty, thus activating the principle of collective defence.[26] Triggering Article 5 could be also relevant in case of future hostile act in outer space.

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Dr Anne-Sophie Martin

is a Doctor of Law specializing in International Law and Space Law at Sapienza University of Rome (Italy). Her doctoral research focused on the legal aspects of dual-use satellites. She is a member of several internationally recognized institutions in the field of space law and policy; and author of diverse publications.

Arctic Space Challenge for NATO Emerging from China's Economic and Financial Assertiveness

By Dr Jana Robinson, Prague Security Studies Institute

Geopolitics in the Arctic

Canada, Denmark/Greenland, Norway, Russia, and the United States (US) border the Arctic Ocean. These countries, together with Finland, Iceland and Sweden form the so-called Arctic Council, a consultative body that has governed, together with the United Nations (UN) Convention of the Law of the Sea, activities in the Arctic. This Council, established in 1996, according to its own admission, cannot implement or enforce its guidelines, assessments or recommendations. That responsibility belongs to each individual Arctic State.[1] This is also evident from the pursuit of raw national interests in this strategic, and now more accessible, region. Over the past decade, two developments have, arguably, shaped the Arctic geopolitics to the greatest degree: the increasing assertiveness of Russia and the growing presence of China.

Although a non-Arctic state, China has sought to position itself as a stakeholder in the region. China's research and scientific expeditions in the Arctic go back to the 1990s. In the past decade its interests there have expanded, encompassing exploration, commercial, shipping, and space activities. Beyond its observer role on the Arctic Council, it has established a narrative beneficial to its interests, including declaring itself a 'near-Arctic state'.[2]

China's Polar Extension to Silk Road

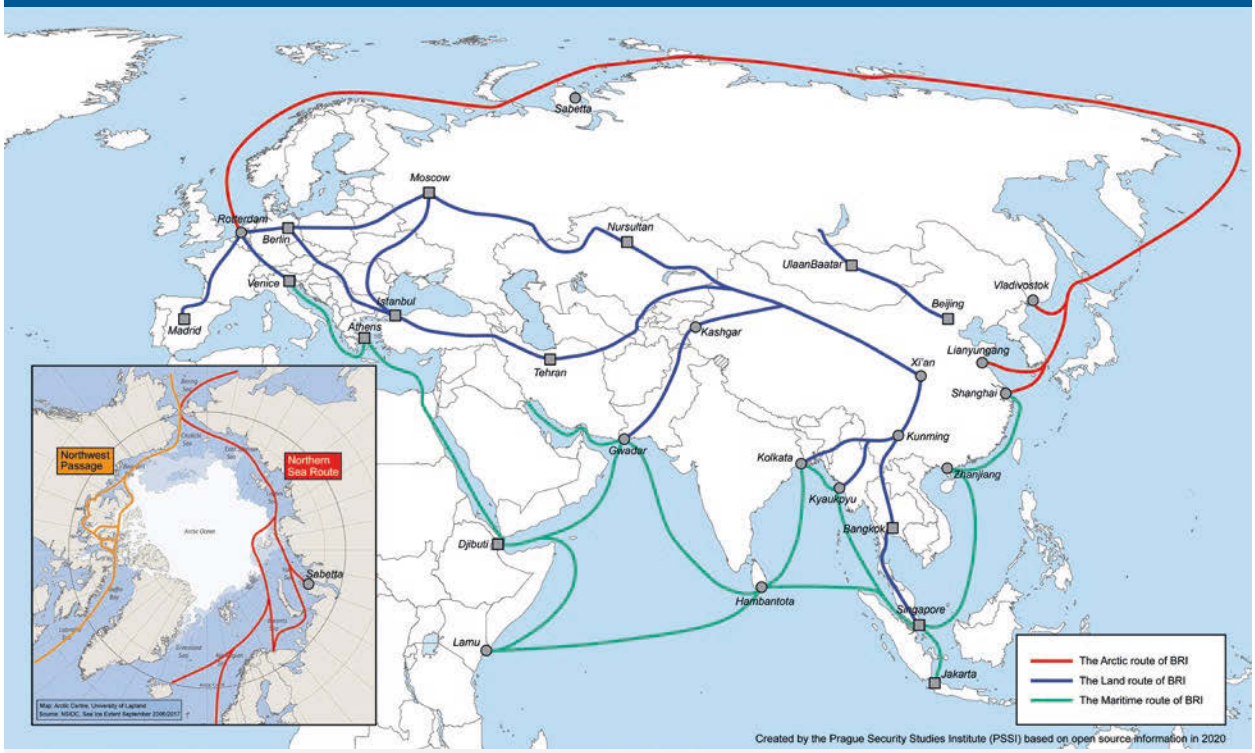

Figure 1: Map of Belt and Road Initiative Routes.

NOTE: *As there is no landmass at the North Pole, sea ice extends all the way to the pole, making the ice subject to the most extreme oscillations between wintertime darkness and summertime sunlight. Arctic sea ice generally reaches its maximum extent each March and its minimum extent each September.*[4]

SOURCES:

Large world map: Created by the Prague Security Studies Institute (PSSI) based on open source information in 2020.
Small world map: Arctic Centre, University of Lapland, Source: NSIDC, Sea Ice Extent September 2006/2017.

In its first Arctic policy of 2018, Beijing points to the Arctic's economic and investment potential, proclaiming its desire to build a 'Polar Silk Road' integrated into its larger Belt and Road Initiative (BRI) and to ensure its freedom to operate in the region.[3] Part of its initial foothold may be the largest Chinese investment in the region to date – the Yamal LNG project with Russia.

China has worked toward building bilateral relationships and provided substantial capital investment in the Arctic Council countries. Its approach has been to use soft power projection, such as emphasizing sustainability, environmental protection and scientific research. Despite this benign-sounding narrative, Norway[5], Sweden, the US, and a number of other countries believe that China's expansive interest in this region is strategic and military. Among the concerns are undue political influence and/or uncontrolled transfers/theft of sensitive data and technologies.

Chinese Space Activities in the Arctic

China's space activities in the region have been expanding. In December 2018, the relatively new Ministry of Natural Resources (MNR), which now oversees the Chinese Arctic and Antarctic Administration (CAA), launched the 'Arctic Environment Satellite and

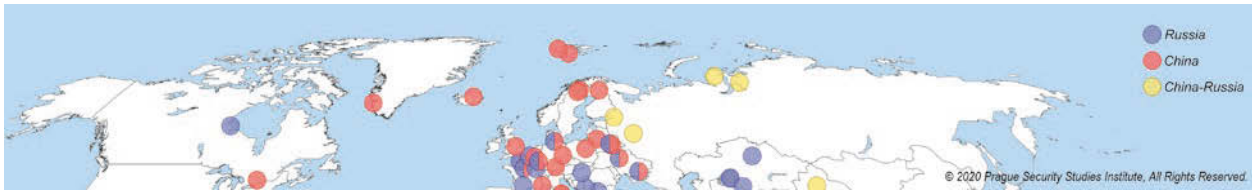

Figure 2: Map of Space Transactions in the Arctic as of June 2020. (Source: Prague Security Studies Institute)

Numerical Weather Forecasting Project'. According to MNR, it is to assist China's role in the governance of the Arctic and in the building of the Polar Silk Road.[6]

Expanding the global footprint of the space ground infrastructure supports China's influence and global power projection as space systems are critically dependent upon its ground segment to provide command and control of the satellites, and also serve as a gateway for mission data such as communications, intelligence, and other data.

Below is a description of Chinese transactions in the Arctic that demonstrate this effort, beyond the scope of their publicly declared vision. China currently has its stations in Kiruna (Sweden)[7], Karholl (Iceland)[8], Ny-Ålesund (Svalbard)[9], and Longyearbyen (Svalbard)[10], and plans to establish ones in Finland (Sodankyla)[11] and Greenland (Nuuk)[12].

Sweden

The China Remote Sensing Satellite North Polar Ground Station (CNPGS) in Kiruna, Sweden (some 200 km north of the Arctic Circle) is run by the Institute of Remote Sensing and Digital Earth (RADI) of the Chinese Academy of Sciences (CAS) and began operations in 2017. Located at the Esrange Space Center, operated by the state-owned Swedish Space Corporation (SSC), it is the first Chinese overseas Earth observation satellite data receive station. CAS declared CNPGS in Kiruna[13] to be an important part of China's Gaofen project (launched in 2010) – a global EO satellite network to be completed in 2020.[14]

Concerns have been raised about its potential dual-use purpose. In January 2019, the Swedish Ministry of Defence's Defence Research Agency (FOI) publicly expressed a concern that the ostensibly civilian co-operation with China could, in fact, be controlled by the PLA and used to supplement military surveillance of the Arctic region with implications for Sweden's national security.[15] SSC also hosts China's ground facilities in Australia[16] and Chile[17].

Iceland

The China-Iceland Arctic Science Observatory (CIAO) in Karholl, Iceland, is jointly operated by Polar Research Institute of China (PRIC) and the Icelandic Centre for Research (Rannis). The project was launched in 2012, based on a Memorandum of Understanding (MoU) between PRIC and Rannis, land was acquired in 2014 and construction began in 2016. The land is owned by a non-profit Aurora Observatory (AO), which would indicate that China changed its approach after the unsuccessful bid in 2011 by Chinese businessman Huang Nubo to acquire land in Iceland and in Svalbard in 2014. Originally it was envisioned that the station will serve to observe auroras, but China proposed in 2017 to upgrade the facility to also enable other types of research.[18] The facility, not far from the Icelandic port town Akureyri, has been operational since October 2018.[19]

The country's willingness to engage in lop-sided co-operation arrangements with China intensified after Iceland's three largest banks (with assets between them 10 times larger than the country's economy) collapsed and caused a financial crisis that lasted several years.[20] They included the currency swap agreement with China of 3.5 billion RMB, concluded in 2010, and extended in 2013, between the central banks of Iceland and China.[21] Iceland also became the first European country to sign a free trade agreement with China in 2013.[22]

The Kiruna S- and X-band station supports Earth observation missions.

Svalbard/Norway

China's Ny-Ålesund Yellow River Station on Svalbard Island has been operating since 2004.[23] Since 2017, it has been managed by PRIC. Previously, it was under the oversight of the CAA. Its building is rented from Norway's Royal Company.[24] The declared purpose of the facility is to use it as an 'integral step for China to improve its understanding about the impact of climate change in the Arctic to other continents, Asia in particular'.[25] It has the world's largest space physics observatory and is able to accommodate 37 personnel in summer and 4 in winter (the highest occupancy of any other country with facilities there).[26] In September 2018, the Polar Research Institute of Hong Kong (PRIHK) established a station (known as the Bauhinia Station) in Longyearbyen, Svalbard, located about 150 km away from the Yellow River Station.[27]

Finland

Chinese investment in Finland was minimal until the period of Helsinki's Chairmanship of the Arctic Council from 2017–2019, during which time China's interest spiked. Ultimately, in January 2019, the success of China's so-called 'check book' diplomacy was evident during President Niinisto's visit to Beijing. At that time, a comprehensive agreement was reached, calling for a China-Finland Joint Action Plan (2019–2023), which laid the groundwork for additional Chinese investment in the country going forward.[28] Implementation of this action plan has included an agreement between Chinese RADI and Finnish Meteorological Institute to establish a joint Research Center for Arctic Space Observations and Data Sharing to be built in Sodankyla, Lapland.[29]

Greenland

Although Greenland, to date, resisted Chinese demarches, it remains a target for Chinese investment. In 2017, rather discretely, a Chinese-funded satellite ground station and a research facility were launched in Greenland, a collaboration between a local Greenland Institute of Natural Resources and Global Change and Earth System Science Research Institute of the Beijing Normal University (BNU).[30]

Interestingly, in 2017, Greenland's Prime Minister planned to obtain funding from Chinese state-run banks for building three commercial airports in Greenland (costing some $555 million), but this arrangement was

terminated after concerns were expressed by Denmark and the US (which has a large military base there at Thule).[31] A year earlier, in 2016, the Hong Kong-based company General Nice Ground attempted to acquire an old naval base in Greenland,[32] but it was stopped by the Danish government over security concerns.[33] It is important to note that Chinese companies hold a stake in uranium and rare-earth mineral (REE) mines there. In fact, Greenland is said to be emerging as one of key components of Beijing's Polar Silk Road as the country has a potential to become another major hub (beyond China) for REE mining.

Key Findings

The examples referenced in the section above demonstrate the incremental approach that China takes in the developed, democratic countries, often through seemingly innocent scientific collaboration which is then expanded beyond the original scope, including into potential military applications. This is in contrast with the offers of vertically-integrated space sector packages (partial or complete) offered by China to developing countries, often including large-scale subsidized financing.[34] Accordingly, China's broader strategic gains in the Arctic are much harder to detect and quantify (including legitimizing of its growing involvement in the region).

China's space sector activities are closely aligned with its 'Polar Silk Road' initiative, a subsidiary of the country's broader BRI, giving the country access to valuable northern latitude land and infrastructure. It is difficult to make a clear distinction between civilian and political-military activities of China in this region, but a connection has been identified between the establishment of the ground stations in the Arctic and the Chinese military.

In short, the Arctic is part of China's global space power projection (and associated economic benefits) the implications of which are not well understood today. NATO would be well-advised to understand, and carefully monitor, this risk environment, including its scale and underlying motives.

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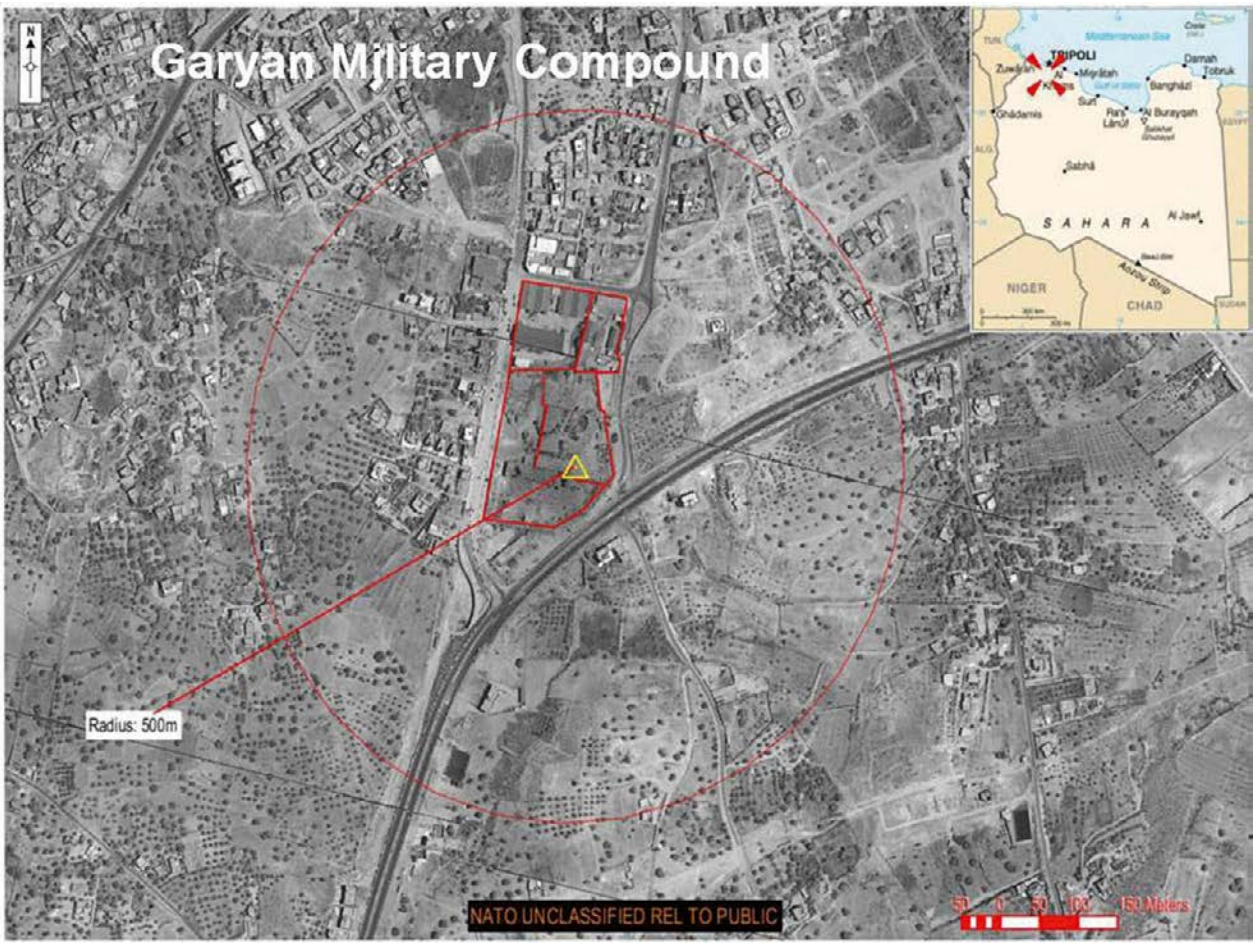
Dr Jana Robinson

is Managing Director at the Prague Security Studies Institute (PSSI). She also serves as Director of PSSI's Space Security Program. She previously worked as a Space Policy Officer at the European External Action Service (EEAS) in Brussels as well as a Space Security Advisor to the Czech Foreign Ministry. From 2009 to 2013, Ms Robinson led the Space Security Research Program at the European Space Policy Institute (ESPI), seconded from the European Space Agency (ESA). Prior to that, Dr Robinson served as Development Director at PSSI from 2005 to 2009 and administered its affiliate organization, PSSI Washington. Ms Robinson is an elected member of the International Institute of Space Law (IISL) and the International Academy of Astronautics (IAA). She is also a member of the Advisory Board of the George C. Marshall Missile Defense Project of the Center for Strategic and International Studies (CSIS). She holds a PhD from the Charles University's Faculty of Social Sciences, Institute of Political Studies. She also holds two Master's Degrees, from George Washington University's Elliott School of International Affairs and Palacky University in Olomouc, respectively.



Using the Space Domain

An Intelligence, Surveillance and Reconnaissance Perspective

By Major Giuseppe Valentino, IT AF, JAPCC

Introduction

In recent years, Space operations have developed into a remarkable field of strategic interest for technologically advanced nations and military activities. In particular, the discussions surrounding Space functions has increased significantly, as has the awareness of the dependence on Space by NATO member countries. It is commonly accepted in the NATO operational environment that Space is a valuable resource, available for military activities and it's a domain which must be preserved against possible intrusions aimed at preventing and limiting the use of assets on-orbit.

One of the highest priorities for NATO is Joint Intelligence Surveillance and Reconnaissance (JISR). The importance of JISR was reconfirmed at the 2014 and 2016 Summits held in Newport (Wales) and Warsaw (Poland)[1], respectively, and implemented in exercise Unified Vision in 2018.[2] One of the most important and crucial aspects in NATO operations is to have Intelligence, Surveillance, and Reconnaissance (ISR) products that are actionable and verified by combining multiple sources. Among the various sources of intelligence available, some of the most effective means of data collection come from Space, in which ISR assets gather information to support operational commanders at all levels.

In the Space domain, the next challenge of ISR is to enhance the awareness of Space-based assets and their limitations, optimizing the coordination among NATO nations and personnel training.

Data Collection from Space

From the Balkans' to the Libyan campaign[3], the use of satellites as a source to collect information has been increasingly prioritized and implemented. An example of this is the Low Earth Orbit (LEO) which has been filled by numerous satellites for improving data acquisition in every part of the world and all weather conditions. Indeed, Space Earth Observation (EO) at LEO altitudes can guarantee a high level of revisit time[4] in many points on the ground for monitoring targets continuously. In the last decade also civilian companies, sometimes in collaboration with national defence systems, have implemented the sensors' capabilities to obtain information (data collection and processing) in which the quality of images released are of a high level of resolution and permit opportunities for Intelligence exploitation.

Furthermore, the advanced technological capability of Synthetic Aperture Radar (SAR) and electro-optical sensors combined with Signal Intelligence (SIGINT) satellites and other ISR sources, allows for a vast amount of data, or 'big data' transfers. To highlight this point, this process could be viewed as a continuous chain of data fusion that interrelates with other intelligence solutions in order to release persistent and accurate analysis.

Space-based ISR assets can also support targeting. In the latest military campaigns, ISR for targeting has been increased by using satellites to provide accurate information on a single target with a high level of precision, including impact points for attacks. Space-based ISR sensors play an important part in the Battle Damage Assessment process. They are part of the toolbox available to the commander in assessing the structural and functional status of targets.

Apart from the challenges of nationally withheld authority over tasking, NATO must realize the limitations and best practices for exploiting these assets.

A primary aspect of Space-based ISR sensors is to understand the real performance of the sensors and satellites, and how to employ assets in the best way. To accomplish this, a high level of training about tasking management and data entry is needed.

Consider, for example, the passage of a satellite used for intelligence purposes in the planning phase and during a land forces mission. In the aforementioned cases, the revisit time on the target should be taken into account, the availability and the technical limits of the sensor as well as the potential activity of disturbance and countermeasures implemented by the adversaries (i.e. jamming in the data download phase, or the simple camouflage of the area of interest).

Space-based ISR Considerations

ISR is one of the five Space force enhancement functions[5] but, contemporarily, it could be the element of supporting capabilities that protects satellite mission execution. In the last decade, new countries have acquired Space-based ISR assets for military and governmental purposes due to their high information contribution, all over the world, so that a certain level of Space services are available in these nations. Furthermore, disruptive technologies[6] are increasing day-by-day and could be rapidly used to fill the gap by new capabilities, particularly in the Space domain.

In a new and complex environment in which the *'globalization and advances in communications are widely believed to enable enemies and adversaries alike to copy NATO countries' state-of-the-art weapon systems, and possibly even surpass them by developing next-generation weapon systems,'*[7] Allies should also consider different and alternative sources of data.

It may be necessary for the NATO Intelligence community to focus its collection on the adversaries' Space capabilities to forewarn of any actions against allied assets in orbit before and during military operations. Satellites might be the first target that a potential adversary tries to engage in offensive action to limit or degrade any NATO use of the Space domain.[8] It will be useful to collect information about the enemy's Space

capabilities and dependencies, in order to identify its weak points. As a primary aim, one consideration might be to analyse whether the adversary has redundancy and synergetic system solutions that also include the use of commercial Space providers.

Another key issue is to understand the enemy's counter-Space capabilities and try to develop the means to counter these or plan for alternative procedures. ISR should not solely rely on satellites but should take into account any sort of limits or influence against on-orbit assets. For instance, the use of images to support targeting evaluation could be disrupted by enemies that have capable counter-Space assets or jamming devices. A factor to be considered is that the oldest generation of satellites does not have equipment for anti-jamming or self-protection.

Further, ISR contributes to improving situational awareness for Space and should be preserved from any intrusion or attack upon military satellites. Many countries have developed anti-satellite capabilities, so the continuous use of satellites during NATO operations is not guaranteed.

The Future of Coordination and Training

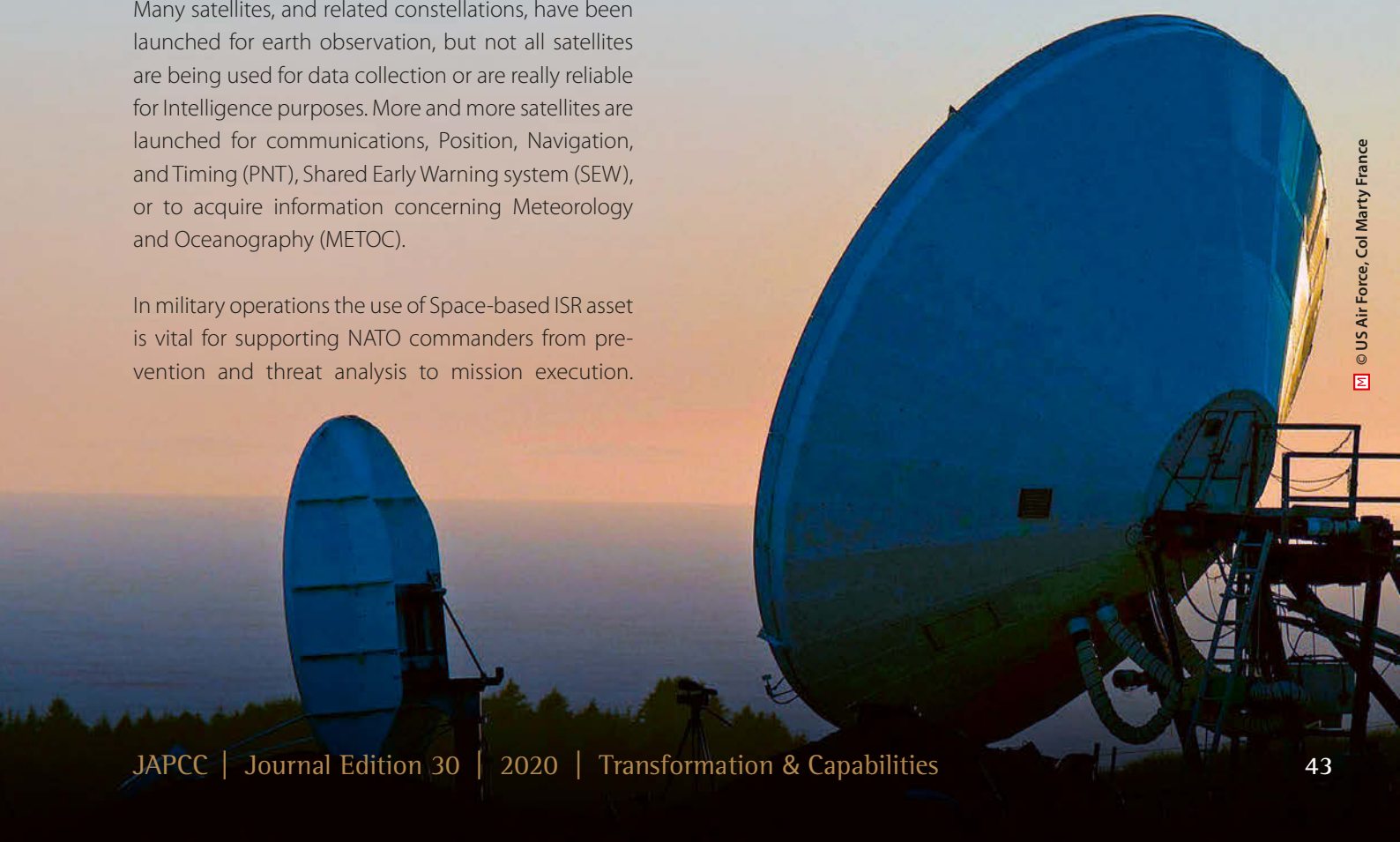
Many satellites, and related constellations, have been launched for earth observation, but not all satellites are being used for data collection or are really reliable for Intelligence purposes. More and more satellites are launched for communications, Position, Navigation, and Timing (PNT), Shared Early Warning system (SEW), or to acquire information concerning Meteorology and Oceanography (METOC).

In military operations the use of Space-based ISR asset is vital for supporting NATO commanders from prevention and threat analysis to mission execution. Therefore, in a complex scenario, it may be important to try to identify the effective demand of ISR in the Space domain.

Many nations have Space-based ISR capabilities, but their tasking is still considered to be as a national 'black-box'. For NATO operations this is a limiting factor for Intelligence collection planning. It means that allied Joint ISR should appreciate their level of awareness of Space-based ISR assets available for tasking. Nevertheless, the critical aspect in NATO's Intelligence community is not just to have data, but also to exploit the data and transpose gathered data into reliable Intelligence. Unfortunately to analyse collected data from Space, and optimize data fusion, requires highly qualified analysts, with expertise, that at the moment is exclusively part of national capabilities.

This gap could be filled by training and improving continuous education for the Space-based ISR professionals or to introduce coordination elements between Space management assets and Commander's Critical Information Requirement Management cycle.[9]

A good step ahead for the Alliance, as evidenced by the last exercise TRIDENT JUPITER, is that NATO has begun to seriously consider Space as a domain playing an important role.



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As a future consideration, it is recommended to build up an ISR cell composed of personnel that have expertise in using Space for Intelligence purposes.

Unfortunately, few allied nations have access to Space for intelligence purpose, even if they have commercial support from civilian providers. In this case, it is essential to identify, through lessons learned, what kind of contribution the nations could provide to NATO commanders in terms of expertise. It might be necessary to understand the level of available systems, data information releasing, imagery analysis capabilities or data exploitation to assure a high level of intelligence redundancy. In other words, the use of commercial Space data could improve the Space-based ISR asset resiliency by acquiring new images in the case of limited satellite availability or in cases of limited national contributions. For these reasons, it may be reasonable to develop a NATO autonomous ISR capability to maximize the coordination among nations' Space assets or build up specific knowledge to combine data collected from other sources.

Concerning the aforementioned topic, it might be reasonable to expand the concept 'need to share' by implementing data policy and resource sharing agreements among nations.

Although we have a long way to go, as mentioned in different NATO official documents and publications for training,[10] and before executing a military campaign it is important to know the level of intelligence upon which commanders can rely. According to consolidated procedures, the NATO Intelligence Fusion Centre (NIFC)[11] may be the point of reference for data collection and exploitation in supporting NATO Intelligence requirements or release basic Intelligence for operational planning. Besides, the level of capabilities required for exploitation should be determined during the force generation Phase to define the level of NATO JISR capabilities correctly.

Conclusion

According to Lieutenant General (ret.) Friedrich W. Ploeger *'NATO JISR is a key enabling capability to achieve information* [superiority] *over potential adversaries. ISR is also a key process in air operational planning'*[12] in which information from satellites will play a noteworthy role to collect data as well as support conventional and unconventional activities.

By contrast, data exploitation from Space might require a higher level of expertise and skilled personnel. For these reasons, training and developing Space-based ISR tasking capabilities to improve the decision-making cycle should be considered in NATO exercise execution,[13] to verify the correctness of procedures and training. Accordingly, the Intelligence community

Copernicus Sentinel-2 mission. Photo shows a part of the Namib Desert in western Namibia.

should be aware of using Space due to natural, technical, and operational limitations that characterize the uncertainty of domains.

In conclusion, the JISR community should be encouraged to globally perceive the importance of Space,[14] be more aware of its advantages and limits, such as satellite performance; set up a new mindset and education for personnel, optimize the process of requesting Space-based ISR products to NATO nations and test new procedures. Collecting data from Space domain might be decisive for maintaining information superiority by increasing a scientific and heuristic model of ISR analysis. ●

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Major Giuseppe Valentino

started his career in 1992 joining the Italian Air Force NCO School in Caserta. During his service worked in E.W. group as an Intelligence Analyst and had two tours to Sarajevo (Bosnia-Herzegovina) and was responsible for analysis and production in the Deployed Intelligence Cell.

In 2005, he was engaged as a Force Protection platoon leader in Kosovo as well as supporting other key NATO operations. From 2010 to 2019 he was Section Head of COSMO-SkyMed operations in Italian Defence User Ground Segment (IDUGS). Major Valentino holds an MA with honours, in Political Science Sapienza University of Rome and an MA (level II) in Peacekeeping and Security Studies University Roma Tre, and currently serves as an ISR Subject Matter Expert at the JAPCC.

Air-Land Integration – NATO's Strategic Joint Challenge

The Importance of Education and Training for Improving Joint Force Interoperability

By Lieutenant Colonel Sarah Fortin, US AF, DACCC, IT
By Lieutenant Colonel Livio Rossetti, IT A, JAPCC

Introduction

As airmen and soldiers working in a joint force environment, various definitions and associations come to mind when discussing the extensive and historically important topic that entails the military effects of Air-Land Integration (ALI). ALI refers to the synergistic employment of lethal and non-lethal effects by Air and Land forces to meet a Commander's intent. More importantly, inherent to this definition of ALI is the *critical coordination* and understanding required between both Air and Land forces to maximize effects on a target and mitigate the risks to friendly forces. Categorized as a 'Comprehensive-Strategic-Concept', ALI ranges from tactical to strategic level processes aimed at seamlessly combining Air and Land forces' capabilities to achieve joint operational objectives. This description of ALI did not evolve overnight but, over the decades since the dawn of military aerial capabilities which were showcased in World War I. For the first time, that war saw the use of aircraft in a major conflict providing relatively long-range bombing and target spotting for artillery forces to refine firing onto an enemy position in support of ground troops. From the First World War to the modern conflicts in Afghanistan and Iraq, there has been extensive coverage on the significance of ALI and how the effective employment of ALI created the military advantages that made the difference.[1] Famous is the statement made by General Bernard Montgomery after 'Operation Compass' in World War II: 'If you can knit up the power of the Army on the land and the power of the air in the sky, then nothing will stand against you and you will never lose a battle.'[2]

Since its debut, ALI has always played an important role in the outcome of military conflicts. Subsequently, it is easy to hypothesize that future Multi-Domain Operations (MDO) will further stress the need for interoperable proficiency in ALI capabilities as a driving factor. It is essential to reflect on what common doctrine, policies, and possible solutions should be pursued by the Alliance to expand and update its ALI capabilities. The joint education and training of its forces are, and will continue to be, the fundamental building blocks for establishing proper tactics, techniques and procedures in MDOs. Despite recognizing the value in the education and training of its forces, NATO currently has a very limited number of formal joint education and training programmes that persistently prepare and cultivate a joint-minded force. Maintaining the current model of stove-piped educational programmes for single component forces is akin to maintaining an unprepared joint force. This 'educational isolation' creates a key strategic issue for the planning and execution of joint force operations.

Origin of Air Operations Coordination Centres – A Joint Seam for Air-Land Operations

After the collapse of the Soviet Union, NATO underwent a major restructuring and reorganization of its forces. Prior to the post-Cold War changes, NATO's Force Structure Air Operations Coordination Centres (AOCCs) were still attached to a land corps, however, they were known as Air Support Operations Centres (ASOCs). During NATO's transition from nuclear deterrence to conventional deterrence, ASOCs were tasked to provide mobile tactical air control system facilities in support of air operations management for the self-sustaining Forward Air Component Command, Control, and Communications Concept.[3] Moreover, the Air Component's Command and Control (C2) plans included integrating offensive air support/interdiction operations with forward-deployed NATO forces operating through ASOCs and respective Tactical Air Control Parties (TACP) collocated with ground forces.[4] These roles and responsibilities have remained primarily associated with today's United Kingdom (UK) and United States (US) national ASOCs, however, these roles are not applicable to NATO's existing AOCCs, despite contradicting allied doctrine. Although current NATO doctrine conveys the best practices of a national ASOC assumed under the roles and responsibilities of an AOCC, it does not accurately reflect today's reality, specifically regarding the staffing, training, and equipping of NATO's eight active AOCCs.

Discovering the Reality of Overestimated Doctrinal Capabilities

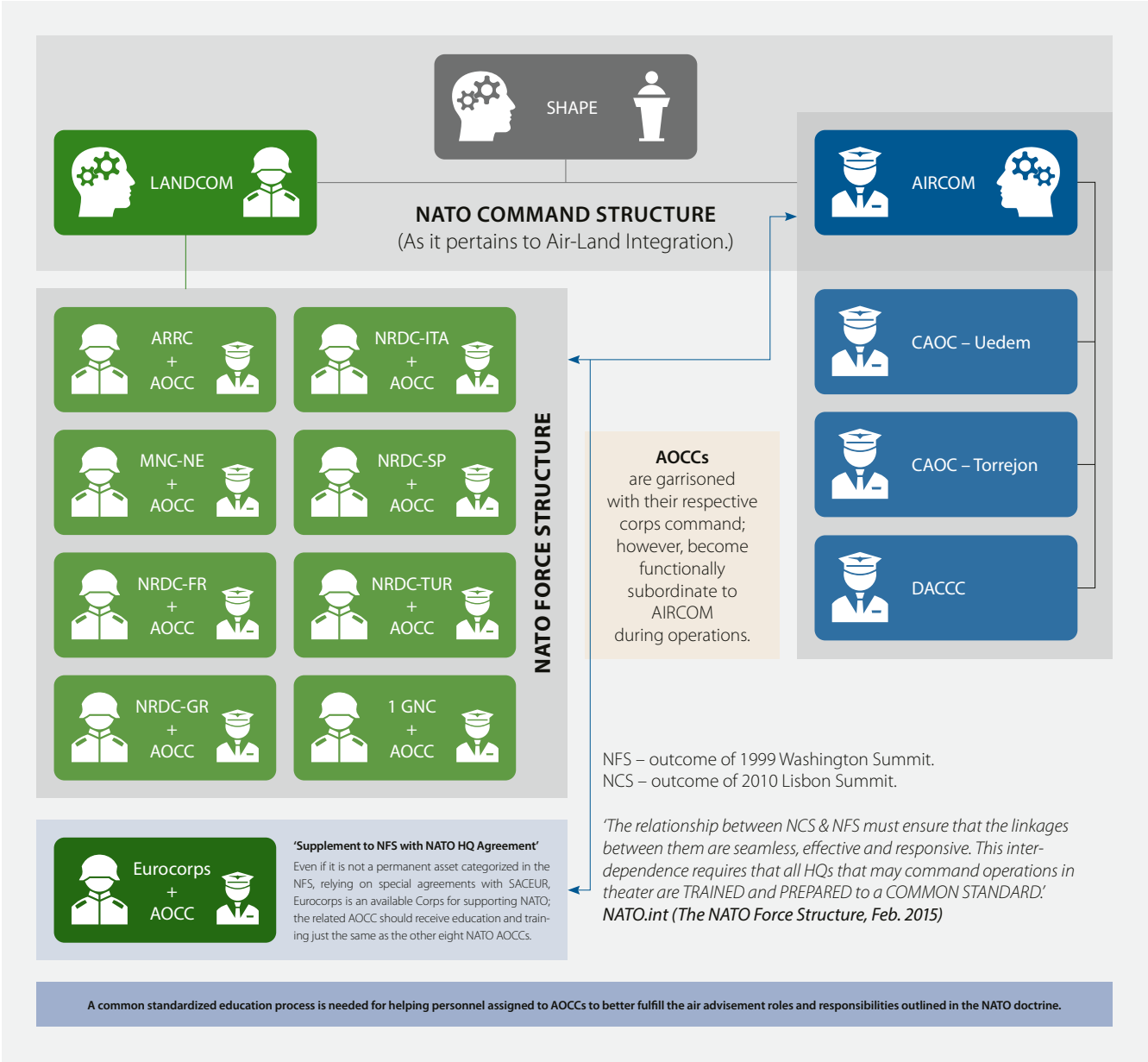
NATO's Allied Joint Publication (AJP) 3.3 (B) for Air and Space operations defines the AOCCs as an 'air entity functionally subordinate to the Joint Force Air Component (JFAC) that is collocated with and is an integral part of an army corps …' It further states that AOCCs provide air expertise and integrates the liaison and coordination functions relating to air operations. Specific to operations and exercises, AOCCs will provide execution-level coordination of air operations in support of the ground commander, as an extension of the JFAC.[5] In a subsequent doctrine revision released in 2019, the extensive Allied Tactical Publication (ATP) 3.3.2.1 (D) mentions that AOCC processes are in close coordination with the corps Joint Fires Support Element (JFSE). These processes include: handling immediate (air) support requests, coordinating the execution of scheduled and on-call Close Air Support (CAS) sorties, and coordinating manned/unmanned aircraft transiting through airspace over the ground force commander's operational area.[6] In addition, the ATP describes that AOCCs, 'when delegated the authority, can re-task/re-role/re-direct airborne assets, provide target updates, and launch ground alert aircraft on call for the ground manoeuvre commander, as required'.[7] Notably, there is an indicated interchangeability between national/coalition ASOCs with the roles and responsibilities of AOCCs. Although ASOCs are not an organic NATO capability, the ATP states in particular cases, ASOCs may exist in place of the AOCC. Despite the doctrine describing that AOCCs are as capable of the aforementioned roles and responsibilities, there is no specific joint education and training provided to AOCC personnel to be able to perform as advertised. Since 2017, through ALI workshops and conferences with AOCC and joint fires personnel, a team of Subject Matter Experts (SMEs) on ALI

at the DACCC and NATO Rapid Deployable Corps-Italy (NRDC-ITA) discovered that the divergence between AOCC capabilities from doctrine stems from a variety of issues. Primarily, the lack of standardized joint education and training of the personnel assigned to conduct Air-Land Operations. As a result, AOCC capabilities have not been exercised properly, leaving them to atrophy to a detrimental level. Frankly put, if NATO were to engage in major joint operations tomorrow, AOCCs could not be employed in the manner which current allied joint doctrine prescribes.

Trending issues gathered from various ALI workshops and conferences highlight that AOCCs have limited understanding on the 'why and how' of their prescribed doctrinal functions, while corps regularly misconstrue what AOCCs do and why they are co-located with them. Since AOCCs are not empowered by standardized education and training to perform their doctrinal roles, they are systematically overlooked or incorrectly employed by both Air and Land leadership. Consequently, the potential for improving NATO Air-Land operations is lost if key joint units, such as AOCCs, are left to determine their *raison d'être*. Perhaps, with consistent dialogue and engagement beyond the annual Trident series exercises, leaders from Allied Air Command (AIRCOM) and Allied Land Command (LANDCOM) can collectively gain traction for implementing mutually beneficial joint education and training opportunities for their forces. If NATO wants to ensure successful joint operations, it must solicit, advocate for, and endorse proposed improvements by subordinate units that bolster the joint education and training of its forces. Military success relies on a joint effort and providing proper joint education and training is the common foundation needed for authentic improvement of ALI at all levels, especially at the strategic and operational level, where the bulk of NATO forces function.

Evolution of a Solution – DACCC's ALI Workshop

In the early stages of fielding NATO's enhanced Forward Presence (eFP) mission, visiting senior officials received several questions and ideas regarding the potential joint integration of eFP battle groups and air support from the Baltic Air Policing (BAP) mission. Though the requirements to integrate two different NATO missions are highly complicated due to the politics involved, the basic ALI question still remained, how would a NATO-led joint operation on the Baltic and Polish front really work? To further explore this concern, the former Commander of the DACCC, present at the official eFP field visit, solicited his experienced instructors to determine feasibility of developing an educational programme that would familiarize rotating eFP forces with NATO joint doctrine. As the department head for JFAC Training[8], providing initial functional education and training for all operations personnel in NATO's Air C2 structure, the DACCC[9] is well-versed in developing and presenting educational programmes. A team of DACCC instructors with ALI experience rose to the challenge by creating the ALI workshop to familiarize eFP and supporting forces with NATO joint doctrinal organization, procedures, and processes. Knowing a single-service cannot present a genuine joint education programme, the DACCC teamed up with Land component joint fires SMEs from NRDC-ITA and Multinational Corps Northeast (MNC-NE) to form the Air-Surface Integration Team (ASIT). Since November 2017, the ASIT has conducted six ALI workshops, catering to a training audience across NATO and national tactical-to-strategic level joint forces. These workshops included key personnel supporting eFP, whom had dealings with integrating CAS and/or joint fires. Using the breadth of experience and expertise shared by the training audience during each workshop, juxtaposed with existing NATO doctrine and force organization, the ASIT was able to gauge the depth of NATO's joint ALI struggles. It became obvious, that ALI knowledge gaps did not solely exist amongst eFP rotational forces, but amongst NATO assigned forces writ large. As a result, the ASIT amended each subsequent ALI workshop curriculum to better educate and help fill these common knowledge gaps deemed crucial to conducting safe and effective joint Air-Land operations. The value of this new joint workshop spread fast, as each one grew in size to a maximum of 21 participants. Several ranking members from AIRCOM, LANDCOM, along with some AOCC Chiefs who attended, praised the DACCC's innovative initiative on providing ALI education in a joint forum. Post-workshop surveys indicated 96 percent of the participants would recommend the joint education forum



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because it taught relevant and valuable information on ALI operations. Information they wished they had received upon arrival to their joint assignment and/or prior to participating in NATO joint exercises.

Advocacy for Joint Education in NATO

Fundamental education programmes for joint forces are NATO's low-risk and low-cost preparation option to keep pace with increasingly rapid changes and anticipated threats inherent to joint all-domain operations. While NATO boasts an extensive menu of 824 courses under its Education and Training Opportunities Catalogue (ETOC)[10], none are tailored to educate forces specifically on ALI operations. With this in mind, NATO must continually assess, adapt, and prepare its forces to combat an array of anticipated threats. More specifically, NATO leaders should regularly assess and associate their strategic concerns down to tactical problems because it may be that some seemingly tactical solutions, such as a joint education programme, will help produce solutions needed to alleviate their strategic concerns. This is why the DACCC ASIT has taken the initiative to refocus, standardize, and advance its legacy ALI workshop to propose it as a NATO-selected joint

educational course. The new course is geared towards better preparing the airmen and soldiers assigned to support ALI operations, especially those assigned to AOCCs, joint fires support elements and other joint liaison roles. The utility of a joint education programme will prove most valuable for NATO forces, as it not only provides them with useful information, it cultivates trust and joint personnel relationships which are essential for operating in a volatile, uncertain, complex and ambiguous strategic environment.

Formalizing Joint Education with Functional AOCC Integration Training

In close collaboration with AIRCOM HQ and the expanded network of ALI stakeholders in NATO, the DACCC is building on its successful ALI workshops by developing a week-long course called Functional AOCC Integration Training (FAIT). The new course is designed to help standardize the knowledge base across AIRCOM and LANDCOM personnel who will work in AOCCs, Joint Fires Support Elements (JFSE), and joint liaison roles. It will incorporate two days of academics on Air and Land processes and capabilities, one day of joint planning for movement into phase three operations, one day of joint ALI operations execution, and one day of joint lessons learned and doctrine discussion. FAIT will be presented as a pilot-course later this year to key ALI stakeholders for vetting and validation. If FAIT is well received, the follow-on progression of implementation is to align it with the second week of the DACCC's existing and successful Initial Functional JFAC Training (IFJT). Doing this will further develop applicable communication skills and joint relations by exposing liaisons and personnel from Air Operations Centres (AOCs), AOCCs, and the Land component to actual coordination requirements, during the Air C2 operations planning and execution phases. Although the DACCC has taken an initiative in improving joint education for ALI, there are other, and perhaps better-suited institutions such as, the NATO School or Centres of Excellence that could fully undertake the aforementioned joint educational task. To help bridge such a transition, NATO could designate a central executive steering group to provide guidance and obtain results in improving joint synergy and interoperability for all of its components.

Conclusion

To ensure feasibility in advancing MDO interoperability in NATO, joint proficiency in ALI mission capabilities must first be attained. To do this, NATO must provide a unified strategic vision for increasing joint operations proficiency through joint education. Integral tasks to achieve joint proficiency, current educational programmes and doctrine must be scrutinized and revitalized accordingly. Implementing standardized joint educational programmes, specifically aimed at the units with liaison roles, such as AOCCs, will help prevent significant divergence between published joint doctrine and the reality of capabilities. The DACCC's initiative in developing and formalizing a course for AOCCs, liaisons, and Land component personnel is but one building block of many required to improve joint force interoperability in NATO. Accordingly, it is of strategic importance that each component seeks innovative opportunities to educate one another, so the sum of their capabilities equals a much stronger military alliance. Strategic alignment happens through consistent dialogue and engagement. The conversation to improve joint operations must be organization-wide, interconnected, and collaborative for joint integration to be a success. Ultimately, persistent preparation of joint forces, ranging from the tactical to strategic levels, through standardized education and training programmes, will help cultivate a joint-minded force to 'lift and shift' its capabilities as one, across all domains.

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Lieutenant Colonel Sarah V. Fortin

earned her commission as a distinguished graduate of the Reserve Officer Training Corps in 2004. She is a Senior pilot with more than 1,900 hours, including combat time over Iraq and Syria, in the C-130E/H Hercules and B-52H Stratofortress. During previous assignments, she served as an Air Liaison Officer (ALO) to V Corps and HQ US Army Europe in Germany. While assigned to the DACCC from 2017 to 2020, she served as the Chief of Dynamic Targeting and Time-Sensitive Targets (DT/TST) Cell, as Chief of the Air-Surface Integration Team (ASIT) and as a NATO-qualified nuclear planner. Currently, Lieutenant Colonel Fortin is the Director of Operations for the 4th Combat Training Squadron (4 CTS) at the USAFE-AFAFRICA Warfare Center (UAWC) at Einsiedlerhof Air Station, Germany.

Lieutenant Colonel Livio Rossetti

was commissioned in the Italian Army in 1993, as an infantry officer. After three years he transited to the Army Aviation schools and graduated as a rotary-wing pilot in 1998. Lieutenant Colonel Rossetti has served as Platoon Commander, Squadron Commander, and S3-cell Chief. He has flown utility helicopters AB-206, AB-205, AB-212, AB-412, as well as the AW-129, Mangusta, combat helicopter. As an aircrew and staff officer, he has deployments to the Balkans Peninsula (Albania, Kosovo), Middle East (Lebanon, Iraq) and Central Asia (Afghanistan). Lieutenant Colonel Rossetti is a qualified CBRN (Chemical, Biological, Radiological and Nuclear) specialist, an airmobile instructor, and he is currently stationed at the JAPCC – Kalkar, as Air-Land Operations expert in the Combat Air Branch.

The New Aircraft Cross-Servicing Programme of NATO

Possibilities and Challenges of the Aircraft Cross-Servicing Agreement

By 2nd Lieutenant Thomas Tüchsen, B.Eng., GE AF, Tactical Air Wing 31 'Boelcke'

Introduction

NATO's military alliance consists of 30 independent countries. For several reasons they have many different types of military aircraft, but in some cases there are multiple nations operating the same aircraft type. For the alliance to use those aircraft in a comparable way, agreements are required to make it possible to achieve similar flexibility. Aircraft Cross-Servicing (ACS), as a military procedure within the Air Force and as an agreement between nations, enables Nations to have their manned aircraft serviced at NATO airfields outside their own territory. The Aircraft Cross-Servicing Programme (ACSP) in NATO has been dormant since 2007. After a request for support[1] to reactivate the programme, HQ AIRCOM supported by the Joint Air Power Competence Centre (JAPCC) re-designed the programme and reviewed all relevant documents. The programme has been reactivated as of December 2018.

Historical Background

In 1952, only a few years after the founding of NATO, the servicing of NATO aircraft outside their own territories was discussed. The result was a document that outlined missions based on both Article 5 and non-Article 5 missions, of the North Atlantic Treaty.[2] To meet the requirements of international support, national and multinational structures of NATO were required to allow operational commanders to launch tactical aircraft away from their main-operating bases, using personnel and equipment from other nations. To achieve this, the Headquarters Allied Air Forces Central Europe (AAFCE)

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established a working group to study the standardization of cross-servicing of tactical aircraft within continental Europe. The working group was technically directed by the Supreme Headquarters Allied Powers Europe (SHAPE).[3] This was a result of previous exercises, identifying that standardization had to be done to get a good working programme.[4] In 1954 however, the implementation of the ACSP seemed unrewarding and nations favoured bilateral agreements.[5] Regardless of the fact that many nations preferred bilateral agreements, the first Standardization Agreement (STANAG) was ratified in the 1960s.

In the following years, the need for cross-servicing of member states and institutional actors was repeatedly raised, resulting in the improvement of the STANAG.[6] In 2007, due to a change in the NATO Command Structure and a lack of requirements, the ACSP entered a dormant stage. However, some nations continued and successfully developed the ACSP on the basis of bilateral agreements. Germany, currently offering the largest range of services for a wide variety of visiting aircraft, stood out in particular.

In recent years, NATO and the JAPCC worked on the reactivation of ACSP and revised, simplified and adapted the complete standardization. The European Air Group (EAG) has also recognized the necessity of ACS and joined the two parties to continuously develop the programme.[7] The new STANAG 3430 has now been reactivated by NATO and constitutes the agreement on the implementation of several ACSP documents.

Why is Aircraft Cross-Servicing Important?

The Allied Aircraft Cross-Servicing Publication-13 (AASSEP-13) describes the aim of the ACSP as follows: *'The primary intent of the Aircraft Cross-Servicing (ACS) Programme is to be a force enabler for operational commanders by proving flexible and affordable means of achieving rapid regeneration of available manned aircraft. The secondary aim is to provide a solution for reducing the logistic footprint and to maximize interoperability.'*[8]

One of the challenges of increasing the possible operational area of a military aircraft is the limited availability of Air-to-Air Refuelling (AAR). AAR enables an aircraft to fly longer distances without a stopover, but it is associated with immense costs and therefore only a limited alternative. Increasing the amount of AAR could subsequently reduce the need for ACS in some areas. However, this programme will also enable commanders to respond quickly, by increasing the flexibility and mobility of deployed air forces.[9] Further challenges are the transfer of air forces and their rotation, the rapid deployment into a possible defence scenario and the evasion to other airfields. ACS could be one of the programmes to increase resilience.

In addition, there are technical aspects which need to be considered and which require an ACSP. In accordance with the current regulation, a flight service inspection must be carried out before, between and after a flight. The aim is the early detection of faults, replenishing resources and applying aircraft configuration changes. Furthermore, a flight service inspection only has a limited validity, which means that after a certain period of time a full inspection by a licensed mechanic must take place. The ACSP does not replace a full inspection by specially trained and licensed mechanics, but it allows operation of aircraft outside the host nation within certain limits and thus satisfying the safety and airworthiness aspects.

The pilots are also well-trained to carry out flight-service inspections on their aircraft if required. However, they are not sufficiently technically trained, as this is not their normal job. Also, the performance of such an activity would place an additional burden on the pilot and also restrict their possible flight service and rest periods during peacetime flight operations. In addition to these routine activities, which are necessary for flight operations, the pilot, especially for fighter aircraft, needs further support in supplementing ammunition and weapons.

The process for a flight which requires a stopover in a foreign country should be supported by trained personnel. NATO, together with its partners, has military airfields in almost every area of NATO territory where aircraft technical personnel are available. Therefore, it

is essential to train personnel about the aircraft of their NATO partners. Like that, these personnel can be employed to reach the alliance's goal of cross-servicing within NATO according to STANAG 3430.

The Aircraft Cross-Servicing Programme

The agreement of all participating nations to the ACSP is recorded in the already mentioned STANAG 3430. It consists of the Allied Command Operations (ACO) Directive 80-53, the new Allied Aircraft Cross-Servicing Publication-13 (AASSEP-13) and subdivided special regulations such as aircraft-specific instructions, ground handling, equipment and training.[10]

The responsibilities for the new ACSP are described in the ACO Directive 80-53. The strategic management is being carried out by SHAPE and the management of the ACSP is done by AIRCOM. In addition, every single NATO nation has an executive responsibility. Any nation

can assume the role of the sending or receiving nation. A sending nation needs support for its aircraft while the receiving nation supports a visiting aircraft.

In the new ACSP, the programme description, requirements, implementation and validation have been fundamentally revised and separated from the old agreement, the Allied Command Europe (ACE) Directive 80-53. In addition, duplications from other STANAGs were filtered, transferred and summarized in the AASSEP-13.

The New Aircraft Cross-Servicing Programme

The new ACSP was developed out of the preceded programme. To be able to carry out all the necessary work on the aircraft, the programme includes more than technical work on the aircraft. It also covers operational tasks such as debriefing, re-tasking and mission planning.

There are different levels representing the required and permitted range of services on aircraft. In the former ACSP, the service levels were divided into three stages: STAGE A, STAGE B and STAGE C. The new programme is dividing the service levels into two main areas, Basic Cross-Servicing and Mission Cross-Servicing. Mission Cross-Servicing, although referred to some parts of this standard, is not completely defined as it is going through a full revision.

Basic Cross-Servicing is similar to the former STAGE C and includes work that can be supervised by the aircrew. These contain refuelling, marshalling, ground handling, replenishment of fluids and gases (like Oxygen), starting of the engine and removal of safety devices of the weapons system. This level also covers optional capabilities which were previously written in STAGE A.

Mission Cross-Servicing includes the work of Basic Cross-Servicing and also covers the capabilities for mission planning and weapon loading. This function, formerly known as STAGE B, is currently inactive and awaiting a full revision as mentioned before.

Each participating nation, the sending nation and the receiving nation, is responsible for providing the training necessary to maintain this capability. As a result, exercises will be carried out at regular intervals to evaluate the capabilities and to further develop the programme.[11]

Challenges

Most nations contracted their own country's industry to manufacture ground equipment and materials to maintain their aircraft. Unfortunately, this is often only adapted to one aircraft type and is not always according to the NATO standard. Therefore, it cannot be used on every NATO aircraft. This resulted in the manufacturing of applicable adapters, to carry out equipment supplements. NATO recognized this problem as early as 1952 and commissioned each nation to provide suitable adapters.[12] However, due to the diversity of aircraft, suitable material is still not available everywhere.

'The Aircraft Cross-Servicing Programme is a necessary and … suitable procedure to increase the flexibility and expand aircraft range limitations …'

A new challenge for the ACSP is that some nations like Hungary and the Czech Republic do not own their military aircraft (Saab JAS 39 'Gripen'). They lease them from the non-NATO nation Sweden.[13] In some cases these contracts require that only personnel from their own country may work on the aircraft, which severely restricts the ACSP. The officer responsible for the ACSP at HQ AIRCOM said *'There are ongoing talks with the aircraft owner and manufacturer to formalize the ways to allow Basic Cross-Servicing. It is expected to be feasible to do it.'*[14]

The implementation of cross-servicing of 5th generation aircraft is another challenge. Several NATO nations are replacing their 4th generation aircraft with F-35s (USA, ITA, GBR, NOR, NLD, DNK, BEL). The maintenance of 5th generation aircraft faces additional challenges, mainly related to the security aspects of the platform and its systems. Some owner nations are addressing these challenges with the appropriate entities, assuming these challenges might be solved in the (near) future.

A solution to the challenge posed by the European NATO members could be the full implementation of the European Military Airworthiness Requirements (EMAR) regulation. Since 2008, the European Military Airworthiness Authority has been developing this regulation to harmonize the standardization of military aircraft, materials and personnel.[15] The newer European aircraft types, like the Airbus A400M, are already EMAR certified. The certification process for existing aircraft however, would take a long time. This would not be a satisfactory for short- to medium-term solutions, nor is it applicable to other nations outside Europe, such as the United States and Canada. Although in the long-term they might sign up voluntarily to comply with EMAR.

It is questionable whether NATO will ever get to Mission Cross-Servicing. As already mentioned, NATO's plan also includes the ability to carry out this stage of service. However, the financial and personnel involvement of nations in Basic Cross-Servicing is already limited, making the expansion to Mission Cross-Servicing unrealistic at present. In addition, national regulations regarding the requirements for obtaining and maintaining the qualification of ground personnel and thus airworthiness are currently not flexible enough to meet the requirements. The SME of Logistics of the JAPCC names a possible solution to this problem: *'One solution might be to form multinational, forward deployable teams ready to administer aircraft servicing on very few Strategic Bases, selected through dynamic planning according to the potential threat or counter-attack mission. The deployment of a multinational team could also solve the security problems of the 5th generation aircraft, which are solved by special licensed personnel.'*[16]

Conclusion

The Aircraft Cross-Servicing Programme is a necessary and, above all, suitable procedure to increase the flexibility and expand aircraft range limitations in the future. There are many and various challenges in implementing this NATO-wide programme. This has already been demonstrated by the fluctuating development spanning 70 years, which has still not reached its final goal. The need for a common defence policy legitimizes further the ongoing work on ACS and, with the new ACSP, will definitely lead to more frequent ACS between nations and allow NATO Air Forces to work closely together again. ●

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2nd Lieutenant Thomas Tüchsen

joined the German Air Force in 2009 after his training as an Aircraft mechanic. Until 2014 he served as First-Line Mechanic at the weapon system Eurofighter. As part of a 3.5-year dual study Programme, he acquired the profession of a state-certified technician. In 2015 he worked as a flight data analyst for one year before he was given the opportunity to become an officer. From 2016 to 2020 he studied at the University of the German Armed Forces in Munich. He is currently working as a flight technical officer in the First Line Maintenance of TaktLwG 31 'Boelcke'.

Hybrid/Electric Aero-Propulsion

Enhancing the Requirement Trade-Space

By Dipl.-Ing. Christoph Müller, Head of Defence Research at German Aerospace Center (DLR)
By Dr Borys Łukasik, Lukasiewicz Research Network – Institute of Aviation

Introduction

The use of electricity is part of the history of aviation from the very beginning. From the first electrically-powered airship in 1883 to an electric-powered helicopter used as a tethered air observation platform in 1917. Ever since those early days of aviation battery systems have been the limiting factor for sustained electrical flight. It took another fifty years for the first fully electrical flight of an aircraft to take place in 1973, quickly followed by the first flight of a manned aircraft powered by solar cells in 1979. Two decades later, the first certificate of airworthiness for an electric-powered aircraft was granted in 2003.[1]

In the meantime, a steadily increasing number of electric sub-systems and consumers across all air platforms, as well as a trend towards a more environmental friendly air travel, have resulted in a considerable number of projects and concepts in the field of hybrid/electric or electric aircraft leading to serious alternatives to conventional air-breathing engines.[2] Notably, that development of alternative technology is not limited to civilian applications such as Urban Air Mobility or other commercial aircraft; military aircraft have always had a high demand for more electrification since the 1940s Boeing B-29 'Superfortress' right through to the modern Lockheed Martin's F-35.[3]

Far too often procurement programmes in aerospace and defence enterprises experience major delays or costs overruns related to design changes, supply chain issues, testing and manufacturing complexity.[4] Some of those are caused by frequent changes of requirements over time or the misunderstanding of potential and risks emerging from novel technologies.

Therefore, it should be an imperative to better understand and to determine the requirement trade-space between high-level capabilities down to the emerging technological opportunities that are feasible in the envisioned timeframe.

First and foremost, operational long-term requirements have to be aligned with doctrinal and strategical frameworks such as The Allied Joint Doctrine for Air and Space Operations and NATO's Joint Air Power (JAP) Strategy. Those underpin *'Speed, Reach and Height* as the core principles of Air Power'[5], while at the same time inherent limitations of Air Power *'such as impermanence, payload limitations and relative vulnerability'*[6] need to be taken into consideration for the core roles defined by NATO's JAP Strategy.[7]

One core role, Air Mobility, has to serve across the air, land and maritime domains *'such functions include the deployment, sustainment, relocation, and recovery of military or civilian personnel and materiel'*[8]. The recent shift in the security environment has made it indispensable to refocus and enforce nations' capacities to project capabilities in a sustained manner. Consequently, modern capabilities and sufficient capacities of the Alliance need to be balanced between the reality of nations' budget constraints and the challenges of the security of global supply chains.[9]

Generally, the future environment in which air mobility is expected to operate is extremely complex. Its requirement is not limited to state, non-state, military forces or terrorism, but is cross-cutting across all domains, while it continues to develop and evolve globally.[10]

Tactical Air Transport – Implications on Requirements

As part of Air Mobility, Air Transport (AT), and more specifically tactical Air Transport, is utilized by three types of assets – fixed-wing, rotary-wing and tilt-rotor.[11] The importance of tactical AT capabilities to ground, amphibious, maritime as well as air manoeuvre warfare is widely recognized. In this respect, tactical AT adds speed and reach to a broad range of operations across all domains such as routine inter-theatre air-bridges or full-spectrum airborne operations.[12]

Despite a current tactical AT focus on the challenges of future operations in littoral Megacities, NATO's Area of Operations ranges from the High North, through Eastern Europe to its South-Eastern borders. Correspondingly, missions will need to be carried out under 'Cold & Wet' to 'Hot & High' conditions including long-distance or endurance operations with the need for fast manoeuvre carrying as much cargo as possible.[13]

The aforementioned range of missions and environmental constraints will naturally have implications on current and future tactical AT platforms, which can be directly translated into speed, reach, height, impermanence, payload limitations and relative vulnerability of those assets. Furthermore tactical AT aircraft are required to operate with great exposure to the enemy threat and under constraints of limited logistic support as well as infrastructure. For fixed-wing missions this includes performance-limiting, austere landing strips,[14] while rotary-wing and tilt-rotor operations are expected to begin and end on land or on sea with limited logistic support.[15] In addition, typical missions of rotary-wing and tilt-rotor assets will include extensive hovering or quick entry and exit while dropping or picking up cargo.

For instance, air-breathing engine rotorcraft operations in 'Hot & High' environments with low-density air conditions face a number of constraints, including: reduced speed, limited height and reach, reduced payload capacity, and an increased vulnerability due to hampered manoeuvrability. Far too often, these individual elements sum up to poor performance causing injuries or deaths and the loss of the aircraft. Traditional technical means to increase performance are primarily limited to more engines and/or more powerful engines, increasing at least the logistic footprint of the individual aircraft, impeding the demands for *'more operable, maintainable and reliable than existing designs.'*[16] It should be noted that, unlike in other mission areas, *'the use of emerging technologies has not significantly influenced the next generation of [air] transport platforms.'*[17] Hence, further requirement trade-space analysis is needed to support well-informed decisions to overcome restrictions cause by a limited knowledge of the solution space providing alternative causes of actions.[18]

Future operational capability requirements for tactical AT are generally well documented and agreed upon by military experts. In contrast, potential technical

◀ **Figure 1: Illustration of potential platforms for tactical air transport that could benefit from hybrid/electric aeropropulsion.**

solutions vary in their maturity and sometimes indicate little understanding of actual operational requirements, or none at all. They can impose high risks and costs associated with individual elements, which hamper national procurement processes. Ultimately, technologies have to benefit the identified key performance parameters of future tactical AT assets such as[19,20,21]

1. **High operational flexibility and availability,** through increased freedom in design requirements (e.g. push rotors) and on-demand power augmentation and (temporally) reduced signatures such as noise or infrared.

2. **High useful loads and performances**, especially by boosting abilities to mitigate most critical and performance-intensive flight manoeuvres (e.g. take-off, landing and hovering) or by generating fuel savings during cruising phases.

3. **High safety and security standards,** by lowering vulnerabilities using distributed design considerations, and by reducing maintenance demanding mechanical sub-systems.

4. **Low Life Cycle Costs,** by reducing the Maintenance, Repair and Overhaul (MRO) associated downtimes and costs of the whole system or its sub-systems.

5. **High reliability and endurance,** by more robust design opportunities to meet the operational arena.

Amongst other organizational or technical means, hybrid/electric aero-propulsion technologies have the potential to provide a vital alternative to traditional solutions by enhancing the aforementioned key performance parameters.

Hybrid/Electric Aero-Propulsion – The Emerging Alternative

Electric devices have been revolutionizing the automotive industry for more than a decade. With every passing year cars become more electrified, utilizing electric systems to improve safety and comfort of driving and at present also to support or even replace standard Internal Combustion Engines (ICE). Electric Motors (EM) are used in regular cars to improve their economy and make them environmentally friendly, and in sports cars to improve their performance. Aviation is following a similar path as the automotive industry – increasingly using electric devices to replace pneumatic, hydraulic and mechanical systems. This is possible through the rapid evolution of electric components leading to more overall efficiency and higher-power densities, which makes them even more interesting for aviation purposes every year.

The impact of electric propulsion on aircraft design might be more favourable than initially expected. While directly replacing ICEs with electric motors could bring advantages of simplicity, reliability, reduced noise and maintenance costs, the far greater benefits may be achieved by exploiting the unique integration capabilities of the electric-propulsion systems within the airframe. Due to the relatively small size and low weight of the EMs, their ability to be scaled down without significant loss of efficiency and the relative ease of distribution of electric power within the aircraft (in comparison to the mechanical distribution of the power) is an advantage in itself.

All-Electric Aero-Propulsion

The use of the all-electric system seems to be the most obvious solution. It would not use ICE and would therefore not rely on fossil fuels or any fuel at all. It would use stored-electric energy instead. This kind of propulsion appears to be ideal from the operator point of view. It has no fuel consumption and its energy storage system can be charged at the airport from the grid. This kind of propulsion system would have a significantly reduced infrared signature and no emissions. Also, the noise would be reduced. The main source of the noise would be the fan or propeller, but there would be no component of noise from the core of a hot gas jet engine.

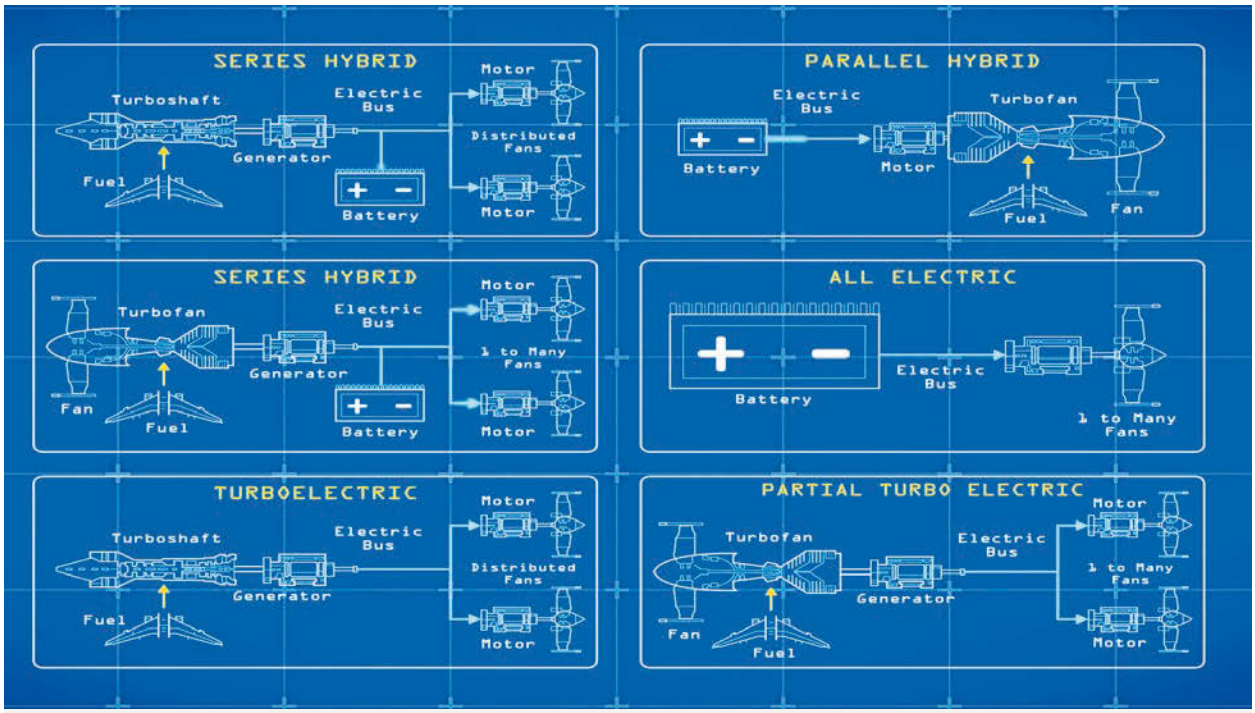

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Figure 2: Classification of electrical powertrains as applied to air vehicles.[22]

The maintenance cost of EMs would be lower than that of a turbine engine. However, there would be an additional cost of energy storage system maintenance, which in case of high-power density batteries may involve the necessity of frequent battery replacement, due to their limited life cycle.

In an all-electric system, there is no danger of hazardous engine flameout due to the fan stall or severe inclement weather (e.g. hail), and obviously there is also no danger of turbine disc burst during a fan-engine separation incident.

The biggest advantage of this concept, from the propulsion point of view, is its extremely high efficiency of conversion of stored energy into mechanical power. While a turbine engine is able to utilize about 50 % of the energy contained in the fuel, the EM efficiency of energy conversion, including transfer losses, can be higher than 90 %.

Obviously the propulsive efficiency would still depend on fan or propeller design. The next advantage of the use of EM would be its natural ability to be overloaded for a period of time, without the risk of failure. That can be very useful during emergency situations and improving safety of flight.

The biggest drawback of the all-electric system would be the energy storage. Currently available, state-of-the-art electric energy storage devices have low energy densities (energy stored per unit mass), which excludes them as storage means for large amounts of energy. For example batteries, which have the biggest energy densities among electric energy storage means, have energy densities more than 60 times lower than the kerosene (~12.5 kWh/kg). Battery technology advancement, which would increase energy density even by the factor of 10 is still insufficient to satisfy propulsion system power demands of a combat aircraft.

High Voltage Electrical Installation	Safety	Performance	Integrated Architecture
• High Powertrains in Constrained Environment • Degrading of Wiring Insulations	• Airworthiness of Components and System • Certification Gaps	• Increase of Power Density • Performance/ Weight Ratio	• Rapid Failure Propagation

Energy Source	Human Safety and Operations	Electromagnetic Hazards	Human Machine Interface
• Failure, Storage and Flammability Characteristics	• Operations in High and Near-High Voltage	• Electromagnetic Compatibility • Electromagnetic Emissions	• Higher Autonomy • Digitalization

Figure 3: Subset of challenges associated to High Power Hybrid/Electric Propulsion in Aerospace[23].

Hybrid/Electric Aero-Propulsion

The best option for using electric energy is to produce it when it is needed, without storing it. A perfect solution for that is to use a hybrid propulsion system, which merges a great energy conversion efficiency of the electric devices and the high-energy-density of the fuel that can be utilized by the ICE.

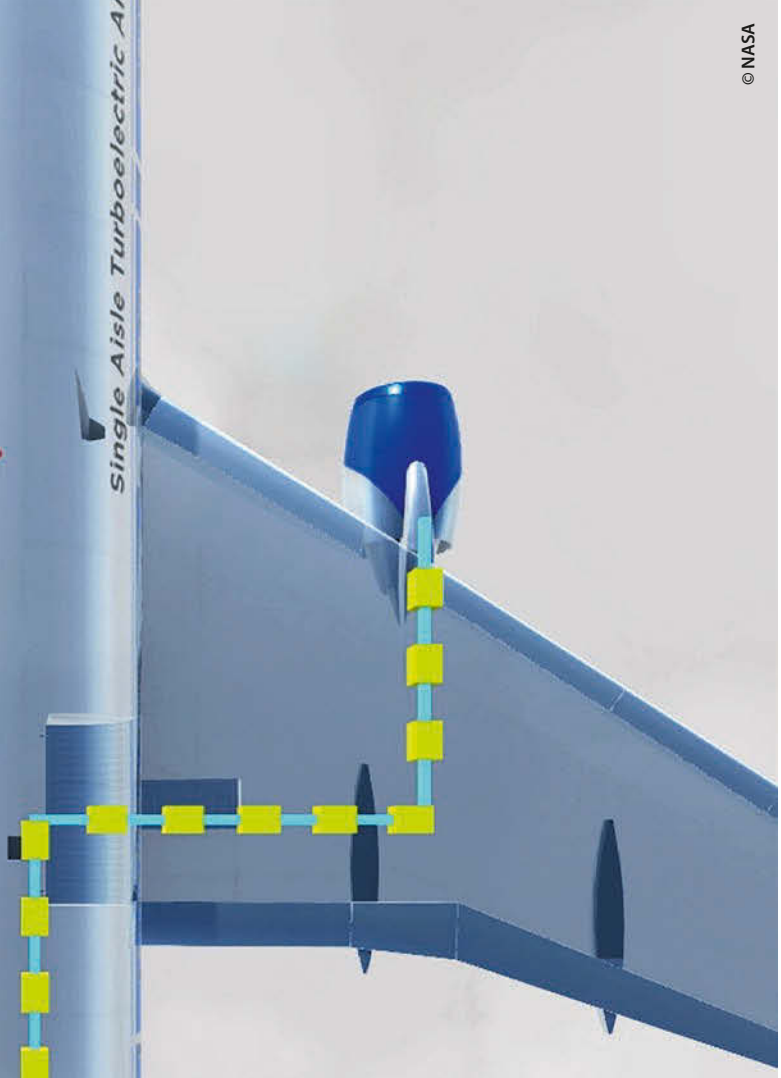
In this kind of architecture, part of the energy is stored in batteries and the other part in the fuel (most likely kerosene). In the ICE, the chemical energy of the kerosene is converted into mechanical energy at the shaft. A generator, driven by the shaft, converts the mechanical power and provides electricity. Electric power is distributed via transmission cables to all the customers which require electricity. An EM (one or few depending on architecture) drives the fan or propellers providing thrust.

In the hybrid propulsion system, the electric motor for the fan/propeller is decoupled from the ICE, and between both, electric devices are mounted, effectively acting like a gearbox with a variable ratio. Use of that 'electric transmission' not only enables fan and turbine speeds to differ, it also makes it relatively easy to distribute power within the aircraft to multiple of such electric motors providing flexibility for a deeper aircraft-propulsion system integration. This provides a vast spectrum of potential architecture configurations which could be of use depending on the class of the vehicle and the mission profile.

Hybrid propulsion systems, just as all-electric systems, would suffer from low energy densities of batteries (and other energy storage devices). It is extremely important to properly consider during which stages of flight the batteries have to provide the desired output. During the other parts of the mission, when batteries are not used but their mass still needs to be carried, they will bring only losses. Determining those breakpoints will be crucial since the volume and weight of the platform have significant impact on the energy consumption and therefore overall efficiency of the system. Without including operational requirements the benefits that the previously discussed propulsion systems would provide might be jeopardized by reduced speed, reach, height or payload.

Enhancing the Requirement Trade-Space – A Conclusion

Some authors argue that technologies had no fundamental impact on airlift capabilities in the recent past.[24] While that might hold for past developments,



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it might be different for the evolution towards more electric aircraft and even more towards the implementation of hybrid/electric aero-propulsion. Its specific potentials and developments have been exploited in the previous paragraphs linking the imperative of Air Power to tactical Air Transport including future high-level requirements.

Regardless of the future military environment or imaginable design concepts, the trend towards more electrical aircraft is obvious as can be seen in civil aircraft and the most modern combat aircraft. First, this is caused because legacy systems such as hydraulic and pneumatic components used for a number of important operations have often suffered from a lack of reliability and high maintenance costs.[25] Second, the trend towards more digitalization (e.g. fly-by-wire) steadily improving handling performance and allowing weight saving. Third, an increased number of consumers such as modern multi-function radars, required computational power, electronic warfare systems and many more have made modern combat aircraft more and more demanding with regards to power consumption.

'Regardless of the future military environment or imaginable design concepts, the trend towards more electrical aircraft is obvious as can be seen in civil aircraft and the most modern combat aircraft.'

Hence, the electric infrastructure of aircraft will need to be adapted from kilowatt to multiple megawatt power transmission, including generating and storing electrical power. The required technologies of battery performance, battery safety/hazard containment, power electronics or safe and light high-voltage distribution are subject to many ongoing researches in nations and international collaborations such as NATO's Applied Vehicle Technology (AVT) Panel. That allows national defence-related research to capitalize on a broad international network comprised of governmental agencies, industry stakeholders and academia.

Ultimately, hybrid/electric propulsion will broaden the requirement trade-space available to augment existing and enhance future air mobility capabilities:

Higher operational flexibility and availability could be achieved by mission-oriented performance adjustments of hybrid/electric engines in up-to real-time.

Higher useful loads and performances could be gained by temporarily augmented ICEs and an increased design flexibility utilizing the advantages of more distributed electric engines.

Higher safety and security standards would be achievable by small and distributed subsystems less dependent on mechanical components.

Low Life Cycle Costs can be enabled by reduced dependency on mechanical, hydraulic and pneumatic systems or subsystems.

Likewise, **high reliability and endurance** of future platforms would capitalize on the potential of hybrid/electric aero-propulsions to reduce dependency on

traditional subsystems as well as to cut down the overall dependency on mechanical, hydraulic and pneumatic systems.

As technologies evolve, more electric aircraft including hybrid/electric aero-propulsion will probably not equally impact on all of the aforementioned key performance parameters. However, knowing the future requirement trade-space between operational requirements and technological advancements will lead to better-informed decisions. Those efforts are supported by NATO's expert committees such as the AVT Panel sponsoring scientific and advisory work in that specific area of hybrid/electric aero-propulsion. ●

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Dipl.-Ing. Christoph Müller

was recently appointed as Head of Defence Research at the German Aerospace Center's (DLR) overall Program Coordination for Defence & Security Research coordinating about fifty cross-cutting projects with a volume of forty-five MEUR. He previously served as the Executive Officer of the Applied Vehicle Technology Panel at the NATO Science & Technology Organization in Neuilly-sur-Seine, France, from 2017 to early 2020. He also served twelve years in the German Armed Forces implementing and commanding a specialized CBRN Explosive Ordnance Disposal platoon including one assignment to the International Security Assistant Force (ISAF) in Afghanistan. Mr Müller holds two Master's Degrees in Mechanical Engineering and Business Administration.

Dr Borys Łukasik

works as Head of Aircraft Propulsion Systems Department at Łukasiewicz Research Network – Institute of Aviation, the Polish National Research and Development Center for Aeronautics. Łukasik's mission is to develop institute's competencies in the field of advanced aircraft propulsion systems, with the main focus on hybrid/electric propulsions, rotating detonation engines and others. Dr Łukasik is also a project leader of the Boundary Layer Ingesting Fan research program.

In addition to the prior responsibilities he serves as a co-chair of NATO AVT Research Task Group 310 'Hybrid/Electric Aircraft Design and STAndards for Research and Technology (HEADSTART)'.

Dr Łukasik is a member of Polish Society of Aeronautics and Astronautics, as well as a member of European Aeronautics Science Network.

The Future of Air Power and the Future of European Defence Industry

By Prof Dr Holger H. Mey, Vice President, Advanced Concepts, Airbus Defence and Space

Introduction

The JAPCC turns 15 – fifteen years dedicated to competence in air power! Unlike sea and land power, both of which also represent geostrategic terms, air power is much less related to the 'classical' notion of 'geography'. For instance, being geographically distant from a crisis does not mean too much in terms of security for a country, just like buffer zones do not offer security for one's own troops, if an enemy decides to use air power. Air power allows the overcoming of the space-time factor in military operations. In its most extreme forms, such as ballistic and hypersonic missiles, it is ideal for a surprise attack. When combined with nuclear weapons, it becomes 'strategic', as it can directly affect an opponent's will by making the perceived risk appear unacceptable. At the same time, it represents the bedrock of deterrence and, hence, war prevention. Of course, air power's limitations are also obvious: air power cannot conquer countries and hold territories and, the flip-side being, it cannot shape any post-war political order. There is little, if any, evidence that air power alone wins wars. But without air power, wars can be easily lost.

If one has to characterize air power in one single word, it is probably 'access': access to territory (e.g. the 1948/49 air bridge to Berlin to overcome the Soviets' blockade), access to targets, access to information and access

to space. Of course, air power – and one should also add space power – consist of many elements covering many roles: it provides the air picture (intelligence, surveillance, reconnaissance and target acquisition), it ensures command & control and communication, it controls the air space (air policing, air superiority, air dominance, no-fly zone enforcement), it conducts integrated air to ground operations (close air support), it provides the bulk of a deterrent force and it enables mobility (strategic, operational, tactical). Air power can quickly shift roles (swing-role) by moving from defence to offence and vice-versa as well as from operations at the strategic, operational, and tactical level. It is a rapid way to influence the behaviour of people or the course of events.

Joint Air Power

This is why the air power role is predominantly joint rather than stand-alone. Strategic air power remains important for dealing with peer competitors, but in the context of many other scenarios it is about enabling and supporting ground troops. At the end of the day, most decisions will be based on the ground situation. It would be a mistake, however, to underestimate the role of air power in the context of ground operations. Hence, the point of some army officers, that all those expensive air assets eat up all resources for the army and there is nothing left to adequately equip the ground forces is somewhat misleading. Investing into air power is actually investing into ground forces' capabilities.

Airlift – strategic, operational, and tactical – does get some of the ground forces, at least those which are relevant in early operations, where they are required. Once deployed in-theatre, ground forces need situational awareness and communication. All of this comes from above!

Ground forces also want to avoid being bombed by enemy's air forces. Hence, air cover is required. One wants to ensure that the adversary's air forces remain grounded. Air defence includes offensive counter-air operations which will play a significant role in this context. Even though some ground-based air defences are organically integrated into the ground forces, the bulk of air defences will be provided by air forces possessing the full spectrum of air power.

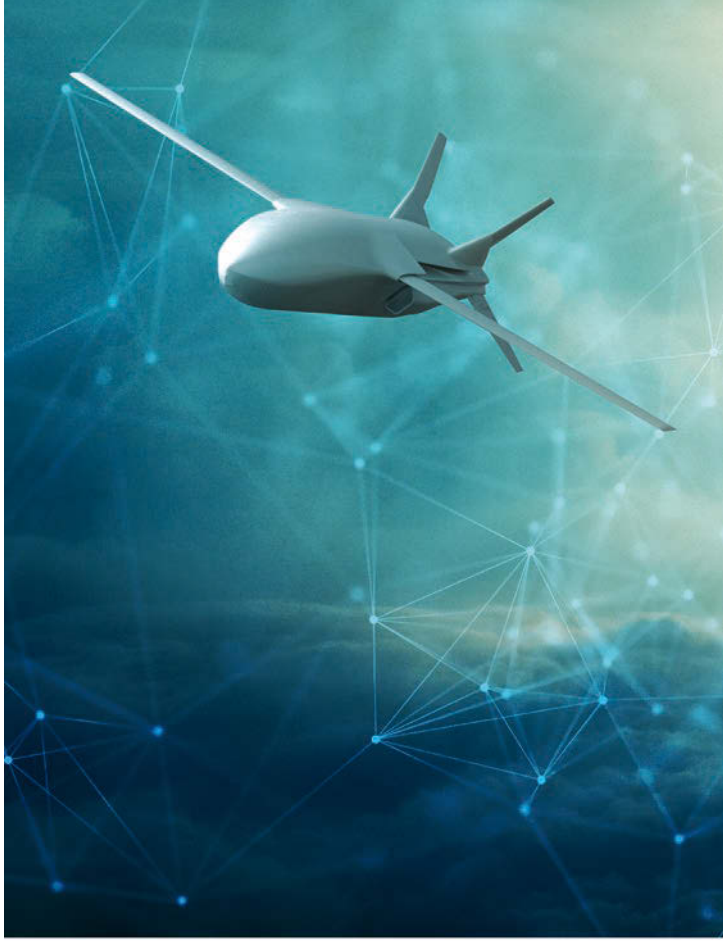
During the Cold War, air superiority in Central Europe focused on defending own territories in case deterrence failed. Today, it is also about achieving air dominance outside of own territories. One needs to own the skies no matter where ground forces are de- and employed. The adversary must have a de facto no-fly zone imposed upon him.

Deployed ground forces require logistical support. 'Precision air-drop' and 'point-of-use delivery' are rather new ways of doing so. The containers are precisely dropped behind the Forward Line of Own Troops (FLOT), the combat zone or the assembly area. Self-destruction is possible in the advent of such containers falling into enemy hands. While it might seem appropriate for ground forces to bring heavy armour and artillery, the political decision-makers might favour a lighter footprint. If so, where would the fire support come from if needed? It will come from above! Close or not so close air support, perhaps in combination with forward air controllers, will play an essential role. When wounded, Combat Search and Rescue (CSAR) helicopters will take soldiers out of the combat zone. Those in a critical state will be bought home thanks to Medical Evacuation aircraft (MedEvac). Hence relief will also come from above!

Air power is the key to supporting ground forces and, hence, should be seen by the army as part of its capability to conduct successful ground operations. Not only does air power support ground forces, it also works the other way around: Ground troops force adversaries to leave their hidden positions thus turning them into targets for ground and air forces. This is at the core of joint operations.

The Constant Challenge

However, air power is constantly being challenged. Whilst air forces might claim that they can destroy any target on the ground, ground forces (or air defenders for that matter) argue that they can shoot down anything which flies. In a sense, both are right. The offence/defence dynamics and the measure/counter-measure competition will always continue, and modern technology will make both ground forces and air forces better



and better (as well as naval and space forces and cyber warfare), but also more vulnerable. One cannot escape this dynamic, since technology development is, despite all differences, a bit like biological evolution. Any offensive capability will lead to the development of better defensive one which will in turn induce new developments on the offensive side. To meet this challenge is as easy as it is difficult: One simply has to be better than the other side.

So, what does the future of air power look like? Stealth will be countered by new sensor technologies, speed will be countered by directed energy weapons, and there will be, at the same time, new ways and means to overcome, fool or destroy the defensive systems. Electronic warfare will play a key role on both sides. Allowing friendly forces to suppress (or destroy) enemy air defences but also supporting an adversary in protecting his own defensive assets and attacking the attacking air forces. Future combat air systems will leverage the collaborative capabilities of connected multi-role manned and unmanned platforms, bringing the next level of air power to increasingly denied environments.

NGWS: © AIRBUS; Sky: Free-Photos/pixabay; Network: © TheDigitalArtist/pixabay

Within such systems of systems, platforms will operate as nodes networked together but also capable of operating on a standalone basis. Within such decentralized, autonomously operating systems, nodes will act as sensors, processors and/or shooters with some dedicated battle managers. Distributing such capabilities across nodes will provide better, faster and more resilient kill paths, the key to survivability and mission success. Air operations might look a bit like submarine operations: completely invisible and silent. Platforms need to operate in radio silence, use passive radar and optronics as well as inertial guidance to avoid detection and dependency on manipulated external navigation data. Teaming manned and unmanned platforms will provide new fields of tactics allowing the combined air packages to seize the initiative against any adversary, by surprising, deceiving, deterring and saturating them.

Red teaming should be part of any development programme in order to anticipate future potential threats and design a force that can deal with technological uncertainties. One must stop planning based on the assumption that the opponent will be incompetent, cooperative or both. To the contrary: The opponent might be very skilled, creative, and nasty. The result of our planning should be insensitive to huge assumption variations. In any case, the technological competition will continue – and require continuous improvement and investments. Technological superiority of today is the standard of tomorrow. Anything planned today, will have to be designed in an evolutionary fashion. Adopting modular open approaches will provide the flexibility and speed to include newer sensing/processing/effect generating technologies to meet future threats.

The Industrial Base

All this requires a strong military Research and Technology (R&T) and industrial base. Of course, this base does not necessarily have to be in one's own country. However, this makes oneself dependent on partners who may one day not be able or willing to deliver arms and equipment. For many European countries, buying United States (US) weapon systems and military equipment is an attractive proposal. Usually the

price looks comparatively good, often the systems are available while European industry lags behind, and, since the US is the most important ally for most European countries, dependencies seem to be an acceptable trade-off. Also, licence production and transatlantic cooperative programmes are one way to ensure that taxpayer's money will, at least partially, remain within the buyer's homeland.

Before looking into the question of sovereignty, autonomy, and competencies, one needs to understand the European arms industry's situation in comparison to the US one. The US has a gigantic defence budget and a much bigger military Research and Development (R&D) budget than all European NATO members combined. The US Armed Forces buy American systems and equipment in huge numbers, whilst exporting 'downgraded' versions combined with close security cooperation and, in some cases, even security guarantees that Europe cannot, or at least not credibly, offer. European industry simply cannot easily compete under these circumstances, in particular if one thinks in terms of unit cost. To do so, Europe needs to significantly increase its defence spending.

Political declarations like the demand for 'European sovereignty' or 'European autonomy' or statements like 'Now it's time for Europe to take its fate into its own hands' are rarely followed by significant increases of defence budgets. Then how can European defence industry be competitive in light of the US challenge? There are simply three good ways for European governments to ensure that industry stays in business: (1) provide contracts, (2) provide contracts, and (3) provide contracts. And one should add: lucrative contracts.

During the Cold War, doing defence business was easier for the European industry. The German defence budget, for instance, averaged around 3.4 % of the Gross Domestic Product (GDP) during the 'decade of détente' (i.e. the 1970s). This did not destroy the German democracy and did not put the social welfare state at risk. And the investment part of the defence budget was around 30 %, while today, Germany has a hard time to go beyond 20 %. All this does not fit well with the declared political objectives and with Europe's interest to be an important player on the world stage.

The position of many European Air Forces, given the budget constraints, is understandable. If the budget is limited, the armed forces want to buy readily available combat power and capabilities rather than to wait for a long-term development programme to materialize. Buying what is military off-the-shelf or available in the very foreseeable future seems attractive. One can always benefit from lower unit costs because of the impressively high production runs of US programmes. However, one can buy cheap and nevertheless end up paying a lot. Call it the 'coffee machine model' or the 'printer model': You are not paying for the machine, you are paying for the consumables. If one does not buy all the new software upgrades for lots of money one can simply expect the fleet to become less capable and even grounded after a while. Continuous investments into improvements need to be done anyway, but the question is who is in control and who benefits financially.

All NATO states benefit from a powerful United States, and a strong US Air Force, no doubt about it. But competition in the best market economic sense of the word makes everyone stronger if supported by adequate budgets. The political objective of many European states is clear: Europe should be a player in the world not leaving it to the US alone to counterbalance Russia and China. This means that the US taxpayer should not pay more for the defence of Europe than the Europeans themselves. When so many nations, such as Russia, China and India for instance, are either strengthening their defence and military aircraft industries or building up new capabilities, Europeans should not take the presumably, but falsely, comfortable position on paying for social welfare and leaving it to the US to defend them.

Europe can compete, and cooperate, with the US and strengthen its position as a world power if it wants to. In the 1960s, nobody would have thought that Airbus could ever compete with Boeing in commercial aircraft. Today these two great companies are at eye level. In the military sector, however, European companies are far from operating on a level playing field with the US. In terms of competitiveness but also in terms of being a competent cooperation partner, Europe needs to strengthen both its defence as well as its defence-related R&D spending and industrial base.

Conclusion

The future of air power is largely determined by the political determination to continue to invest into modern air forces. Technologically speaking, the offence/defence dynamics and the measure/counter-measure competition cannot be stopped. It's a bit like evolution: A virus is infectious, one develops a vaccine, and a year later (or much earlier) a mutation undermines the immune system, and the competitive game restarts. Military competition is an expression of political will. A competitive European arms industry is the expression of Europe's willingness to control its own destiny. This is why Europe must stay in the competitive market for modern air power. ●

Prof Dr Holger H. Mey

is Vice President, Advanced Concepts, Airbus Defence and Space, Munich, Germany, and Honorary Professor for Foreign Policy at the University of Cologne, Germany. Until June 2004, Dr Mey worked as a security policy analyst, TV and radio commentator, publisher, and lecturer. From 1986 to 1990, he was a Research Associate at the Stiftung Wissenschaft und Politik, then in Ebenhausen, Germany. From 1990 to 1992, he served as a Security Policy Analyst on the Policy Planning Staff of the German Minister of Defense. From 1992 to 1994, he became the Security Policy Advisor to the Chairman, Defense Committee, German Parliament.

Dr Mey published more than 150 articles and a number of books, including 'Deutsche Sicherheitspolitik 2030', Frankfurt: Report Verlag, 2001 (English version: 'German Security Policy in the 21st Century', New York/Oxford: Berghahn Books, 2004).

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Cyber-Electromagnetic Domain

The Necessity of Integrating the Electromagnetic Spectrum's Disciplines Under a Single Domain of Operations

By Colonel Matthew Willis, US AF, JAPCC

By Lieutenant Colonel Panagiotis Stathopoulos, GR AF, JAPCC

Introduction

Even though NATO currently recognizes the Electromagnetic Environment (EME) as an operating environment,[1] the latest Libya operations and the Syrian conflict battlespace highlighted that coalition forces might be required to operate within an extremely complex environment in future battles, where the Electromagnetic Spectrum (EMS) might be considered as the fundamental domain of operations. It may be the domain that bridges all the other operating domains allowing the commanders to attain a level of electromagnetic dominance that enables effective employment of more conventional domains in the battlespace. Further, Electronic Warfare (EW) concurrently denies neutralizes, disables or disrupts an adversary's use of the EMS over the area of operations.

On the other hand, in the modern warfighting discipline of EMO, EW is not the only stakeholder of the EME. New capabilities have emerged and are now operating in the EME alongside traditional EW disciplines. In this context, NATO has introduced the

concept of EMO, and the Alliance's nations have agreed,[2] that EMO are all activities that shape or exploit the EME for attack or defence including the use of the EME to support operations in other environments.[3]

Cyberspace[4] – which is also a key stakeholder of the EME – has already been declared by NATO as a separate domain of operations which NATO must be prepared to defend as effectively as it does the domains of Air, Land, Maritime and Space.[5] Nonetheless, some NATO nations have already recognized the convergence between Cyberspace and EW activities[6] and highlighted them under the concept of Cyber-Electromagnetic Activities (CEMA).[7] This synergy has already been effectively employed during Operation Atlantic Resolve.[8] The symbiotic relationship between EW and cyber warfare has also been noted by near-peer competitors of NATO such as Russia, China and Iran. In particular, it is highly likely that Russia's EW and Cyber capabilities have been merged.[9]

While the NATO Framework for Future Alliance Operations (FFAO) highlights the need of operations and effects across all the domains in pursuit of future NATO forces' utopia of Multi-Domain Operations (MDO). The 'Alliance Joint Electromagnetic (EM) Strategy' recognizes the necessity of synergy through greater integration of the EME core functions and related activities such as Cyberspace and Space. This begs the question related to NATO's desire to achieve electromagnetic superiority on the modern battlefield: *'Does NATO need a holistic approach towards integrating all EMS disciplines under a single operating domain in order to achieve the ambitious goal of true MDO?'*

Full-Spectrum Dominance Requires Harmonization of EM Disciplines in the Campaign Plan

During the escalation of the Battle of Britain during World War II, the Prime Minister of Great Britain, Winston Churchill, highlighted[10] that dominance in the Land and Maritime domains requires dominance in the Air first: today that dominance is required not only in the Air but also in Space.

Apart from the prerequisite of air dominance over the battlefield, the latest NATO Strategic Foresight Analysis (SFA) highlights that the future physical environments will evolve towards large urban areas, usually near oceans and more significantly in the developing regions, which will amplify the potential for instability and conflicts.[11] Emerging technologies and the exploration opportunities offered by climate change, along with constant demand on energy resources, contribute to the Arctic region becoming increasingly open to a range of activities such as oil, gas and mineral exploration and leisure activities by Arctic and non-Arctic nations. This access into the Arctic Region increases the likelihood of future conventional military interventions. As a consequence, a NATO coalition force may be tasked in the future for joint operations either in an urbanized geographical area or in an Arctic environment. Hence, battles may encompass a variety of missions, where the increased collateral damage challenges, targeting issues and extreme climate conditions may dictate the compulsory use of non-lethal[12] effects and the non-kinetic[13] weapons of NATO's arsenal.

In the Libya campaign, NATO forces operated in a contested and congested urban environment and the victory against Qaddafi forces was greatly enabled by the use of Air Power.[14] Even though air operations were the main effectors in the Libya conflict, they were not abundant. The Libya urbanized battlefield showed that the usage of non-lethal and limited-lethal activities such as: Intelligence, Surveillance and Reconnaissance (ISR), EW and precision strikes with low yield effects were essential in minimizing fratricides and civilian casualties, and proved to be critical warfighting factors for future NATO military interventions.

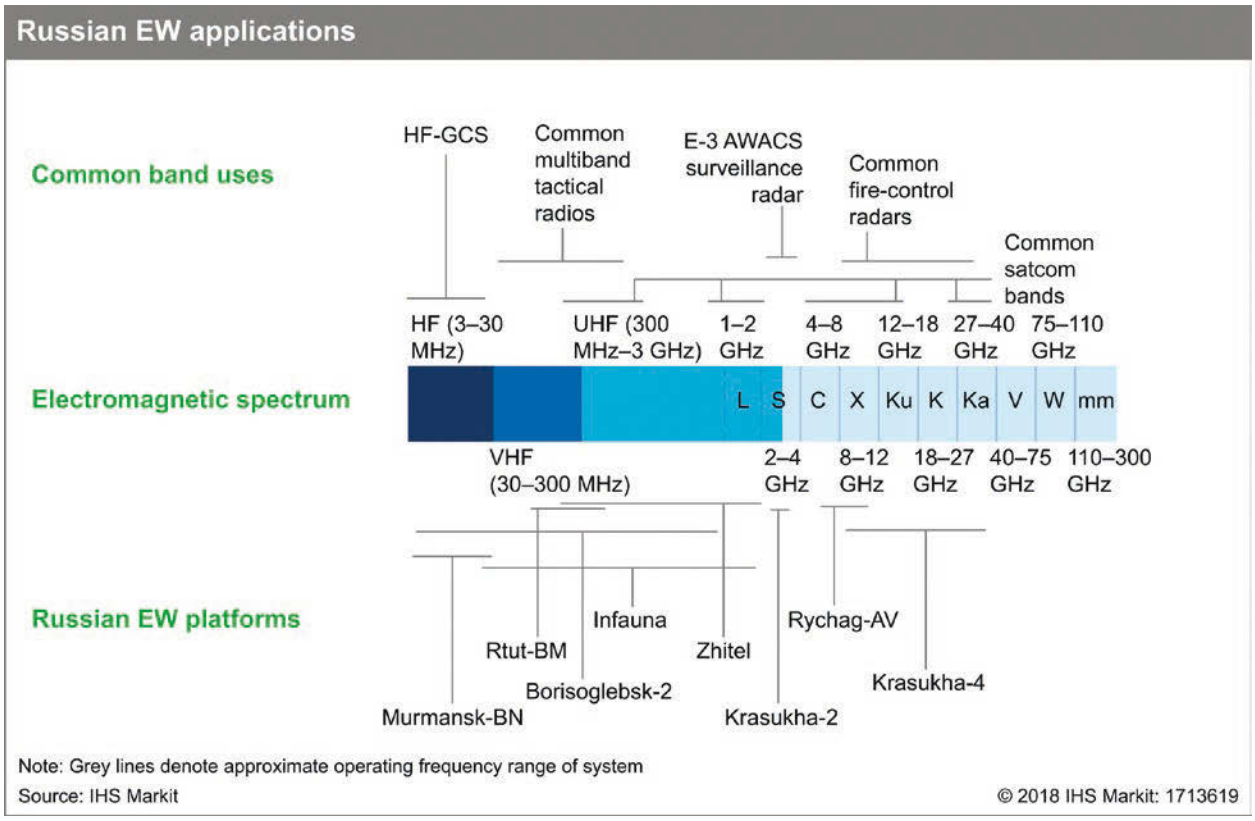
Similarly in the Syrian conflict, it was shown that air superiority was not achieved without having dominance of the EME. Russia demonstrated in Syria, and in the Crimea annexation, that EME capabilities are an integral part of Russian armed forces' modern military strategy.[15] The battlespace in Syria highlighted that advanced Russian EW effects combined with the new sophisticated strategic long-range Surface-to-Air Missile (SAM) system (S-400 Triumf) has brought NATO's ability to achieve air dominance into question.

The differences in the Libyan and Syrian conflicts could be omens, foreshadowing that in the future NATO will only achieve dominance in the Land, Maritime, Air, and Space domains, if the EME elements and functions such as EW, SIGINT and Cyber can be superior by demonstrating synergistic and harmonized activities.

The Common Ground of EM Disciplines Reflects the Need for Synchronization

In the future, NATO will undoubtedly be employed in an expeditionary warfare scenario somewhere around the rapidly-changing world. The rapid pace of technology evolution and the increased use of Commercial Off-The-Shelf (COTS) solutions by near-peer adversaries and non-state actors has allowed them to develop a range of capabilities in the EME for use in symmetric and/or asymmetric military activities. Systems like advanced sophisticated radars and SAM systems are employed in new ways for faster targeting, the fusion of multiple sensors, the creation of unexpected waveforms and operations across the EMS. These adaptations make them harder to detect and jam, or even regain superiority from the adversaries in the 'occupied' EMS frequencies.

The dominance in the EME may not be achieved unless the EMS capabilities and activities are integrated into a single and unique domain of operations. The EMS stakeholders[16] such as Cyberspace, EW, Signal Intelligence (SIGINT), and Battlespace Spectrum Management (BSM) must be unified to an integrated Cyber-EM domain of operations, since Cyberspace was declared a domain of operations during the Warsaw Summit[17] in July 2016. Current NATO Cyberspace policy remains focused on Defensive Cyber Operations (DCO) and has not yet embraced Offensive Cyber Operations (OCO), though it has developed a framework mechanism for integrating cyber effects provided voluntarily by its Allies. While NATO Cyber experts and legal advisors are very slowly considering the implications of pursuing OCO, near-peer competitors have



likely developed doctrine to employ cyber effects, integrated and synchronized with EW and SIGINT activities in their military operations.

Cyberspace[18] is the only domain which has been physically and virtually created by humans employing applications of the EME (e.g. copper wires, fibre optic cables, and microwave and satellite relays) rendering it a part of EMS as well. The apparent common ground which is shared by Cyberspace and EMS fields has been previously acknowledged by United States (US) Army. A US Army study concluded that EW, SIGINT, and Cyberspace could and should share the same staff, processes, and technologies to avoid duplication of effort and to prevent working at cross-purposes.[19] Cyberspace operations overlap with more than 50 percent of EW and SIGINT activities necessitating the great need for operational consolidation.

The perfect example of the EW and Cyberspace interdependency was clearly highlighted during a September 2007 Israeli strike on a North Korean supported nuclear weapons facility in Syria. In particular, a cyber-attack was delivered by an Israeli airborne electronic attack platform, which allowed Israeli forces to virtually take control of the Syrian integrated air and missile defence system, and let the 'highly observable' F-15s and F-16s strike aircraft penetrate the Russian-designed, modern and long-range SAM systems of Syria.[20] This effect could be called a form of 'cyber-stealth'.

In contrast, the Russo-Georgian wars' lessons learned motivated Russia to develop tremendous and modern EW capabilities to counter NATO EMS capabilities. Looking at the figure on page 74, Russia, is not only

looking to deny NATO use of the EMS, but also has employed its EW capabilities in eastern Ukraine and Syria as 'test beds' for refining their tools. In a similar way, the Russian-Ukraine clash (2014–present) has become a Russian Cyber doctrine 'test bed'[21] as well. Russia even employed its cyber-attack capabilities on the Syrian battlefield and demonstrated that cyber is an attractive and low-cost tool for power projection, allowing Russian armed forces to deliver low signature effects without fighting in the Forward Edge of the Battle Area (FEBA).

Dominating in the 'Blizzard'[22] of EMS

In addition to Russia's resurgence, for the first time, the Secretary General recently addressed that the rise of China also poses challenges for Alliance security and he stressed that 'as the world changes, NATO will continue to change'.[23] Consequently, technological advancements such as artificial intelligence, autonomy, and quantum computing, coupled with increased future urbanized areas, will result in operations being conducted in a uniquely contested, congested, complex, and constrained battlespace. Further, operations in extreme climates will trigger an increasing competition among major and resurgent powers across the globe for accessing and governing the EMS 'blizzard'. While NATO planners are pursuing the utopia of MDO, presently no one domain can be the single dominant user of the EME, unless NATO political and military leaders recognize the emerging threat within EME to concentrate efforts into one domain, in order to meet the world's future security challenges. This includes:

Integrating and harmonizing the EM disciplines into the Cyber-Electromagnetic Domain. The great need to employ non-lethal effects on future battlefields in support of MDO effectiveness guarantees the necessity of coherent EMS employment. By unifying the EME stakeholders and challenging them to coordinate and collaborate as a single task force under one policy, doctrine and strategy, NATO forces could dominate in both, the physical (Land, Air, Maritime/Littoral and Space) and the non-physical (Information, Cyberspace and EM) operating domains. Thus, Alliance forces may deliver Offensive, Defensive and ISR synchronized CEMA across the domains in support of future NATO campaigns.

Increasing decision speed and capacity. EME warfighting entities generate, in most cases, non-lethal effects by employing the EMS 'blizzard'. The future battlefield environment, in which the EM effects will be delivered at the speed of light, will create a foggy EME and coalition decision-makers at all levels will be incapable of taking timely decisions or executing the right courses of action in support of a campaign's desired end state without some form of assistance. Consequently, emerging technologies such as artificial intelligence and big data management/fusion should be employed to support the decision-making capacity of Allied leaders, so that NATO forces can acquire the particular EME threat, deny or neutralize it and if necessary, deliver a counterstrike.

Employing the EMS to increase the resiliency. What is old is new again. NATO should exploit certain regions of the EMS such as acoustic, visual and infrared to develop capabilities, enabling NATO forces to be less observable, and increase NATO infrastructure resilience. Advanced camouflage techniques, radar-absorbing materials, decoys or even acoustic sensors and passive radars could be some of the technologies employed to increase the resilience of NATO infrastructure.

In conclusion, future battlefield conditions and security challenges will necessitate the treatment of the EMS as a domain of operations rather than an environment. The EMS is the cross-domain and fundamental glue which binds the other operating domains of Air, Land, Maritime, Cyber, and Space. Integrating the EMS disciplines, functions and related activities into a coherent system will allow armed forces to dominate the EMS 'blizzard' and enable NATO to truly execute the perfect MDO that meets modern-day challenges.

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2. NATO agreed definition.
3. According to NATO agreed definition, EMO include (but are not limited to) Electronic Warfare (EW), Signals Intelligence (SIGINT), Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR), Navigation Warfare (NAVWAR), and Battlespace Spectrum Management (BSM).
4. NATO defines cyberspace as the global domain consisting of all interconnected communication, information technology and other electronic systems, networks and their data, including those which are separate or independent, which process, store or transmit data.
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12. On article purposes, non-lethal effects are relating to non-destructive or non-harmful effects on human beings and man-made objects.
13. On article purposes, non-kinetic means, weapons and methods are relating to or resulting without motion.
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Online at: https://georgetownsecuritystudiesreview.org/2019/06/26/the-russian-edge-in-electronic-warfare/#_edn26
16. Ibid. 3.
17. NATO, 'Warsaw Summit Communique'. In NATO e-Library official texts, 2016. Available at: www.nato.int/cps/en/natohq/official_texts_133169.htm
18. Ibid. 4.
19. Ibid. 6.
20. Richard A. Clarke and Robert K. Knake, 'Cyber War: The next threat to National Security and What to do About it'. New York: Harper Collins Press, 2010.
21. Test bed is metaphorically conveys the concept of testing new capabilities or pieces of equipment.
22. On article proposes, 'blizzard' is employed to convey the concept that EMS is like a unlimited invisible space where large or overwhelming number of things or effects arising or generating suddenly with the speed of light and sharp blow, and cannot be sensed by the human information processing system. 'Blizzard' is also used figuratively to refer to future EMS activities and effects that come suddenly in large quantities and must be dealt with appropriate technology in order decision-makers to acquire the required information, facts, and data in support of military operations.
23. Secretary General Mr Jens Stoltenberg, 'NATO Secretary General's Press Conference following the meeting of the NAC at the level of HoS/G, London, 3–4 Dec. 2019'. In NATO newsroom, 4 Dec. 2019 (accessed 4 Dec. 2019). Available at: https://www.nato.int/cps/en/natohq/opinions_171554.htm

Colonel Matthew Willis

graduated from the University of Cincinnati with a BSc in Aerospace Engineering and entered the US Air Force in 1990. He has been an F-16 instructor pilot, flight examiner, flight commander and assistant director of operations. He has also served as a director of operations and squadron commander of flying training and support squadrons. He is a command pilot with more than 2,400 flying hours, including more than 100 combat hours, and was a SEAD Instructor Pilot in the F-16CJ. Most recently, Colonel Willis finished two consecutive foreign affairs tours as the U.S. Defence Attaché to Poland and as the Air Attaché to Israel. He is currently serving as the Combat Air Branch Head at the Joint Air Power Competence Centre.

Lieutenant Colonel Panagiotis Stathopoulos

graduated from the Hellenic Air Force (HAF) Academy with a BSc in Aeronautics in 1995. He holds an MSc in Human Factors and Safety Assessment in Aeronautics from Cranfield University, UK, and is a graduate of the HAF Tactical Weapons Fighter School. He is an F-16 instructor and functional check flight pilot, and he is a command pilot with more 2,000 flying hours. He has also served as director of operations and commander of the 341 Fighter Squadron from 2012 till 2016. He has served as the Electronic Warfare (EW) including SEAD Operations SME at the Joint Air Power Competence Centre from 2017 until 2020.

The Importance of Integrated Air and Missile Defence Training

A Renaissance of NATO Integrated Air and Missile Defence?

By Lieutenant Colonel G. W. 'Berry' Pronk, NE AF, JAPCC

Introduction

In January 1991, the Netherlands deployed two PATRIOT squadrons under Article 4 of the NATO agreement to South-East Turkey in support of operation 'Desert Shield'. Not long afterwards a third PATRIOT Squadron was sent to Israel, in support of their air defence against Iraqi ballistic missiles. Not more than five days after the initial alert and within 20 hours after take-off of the first wave of mission-essential material

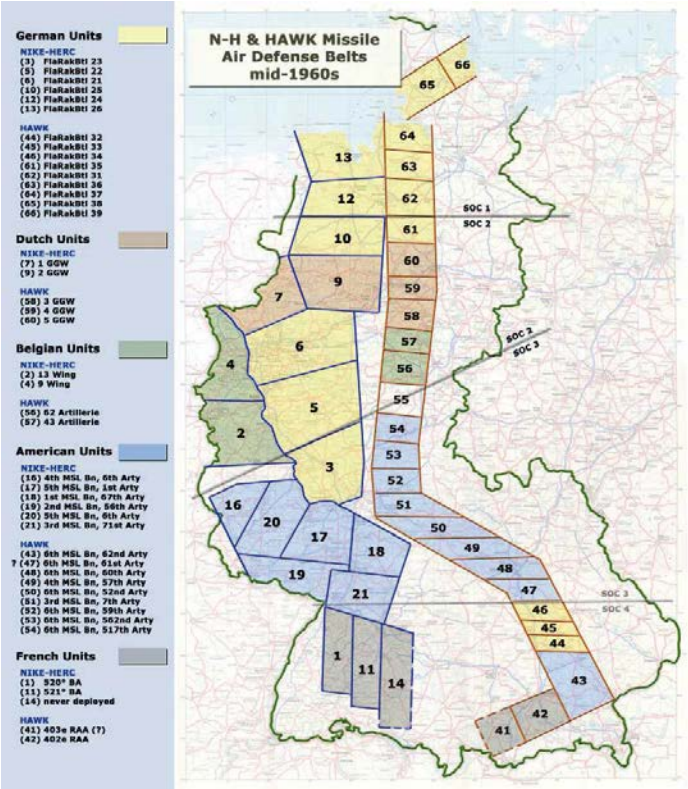
and personnel, the first system reported 'At battle stations', having relocated 3863 kilometres from their initial readiness positions in West-Germany to sites near the Iraqi border.

The entire operation, from the first alert all the way to redeployment three months later, was only possible because the troops had an excellent level of training and equipment, which was ready for battle. Looking at NATO's current capability and the average preparedness level of the Alliance, it appears that we are far removed from that early nineties level-of-readiness. With a focus on Ballistic Missile Defence, we have been neglecting the art of traditional air defence for Ground Based Air Defence (GBAD) units as well as the Air Command and Control (C2) nodes.

NATOs Integrated Air and Missile Defence

NATO's defence of Western Europe during the Cold War was structured into areas of responsibility, where the ground forces were responsible for their respective Corps areas and the tactical air defence forces protected the area above them (see figure on page 80). To be able to counter a surprise Soviet (air) attack, air defence forces were at a state of high readiness, 24/7.[1]

The NATO integrated air defence consisted of multiple layers of different Surface to Air Missile (SAM) systems, combined with air defence fighter aircraft, each in their own designated areas. Coordination took place through very precise procedures, guarded and executed by dedicated Air C2 nodes.



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After the Cold War, the C2 nodes of NATO's Integrated Air Defence System (NATINADS) were rapidly dismantled. National C2 nodes shrank to the minimum needed for peacetime operations and NATO kept on reducing its C2 entities until 2011. At this point, an absolute minimum of C2 entities were kept operational to manage the peacetime mission. For NATO's Air Command (AIRCOM), this meant that from an original nine Combined Air Operation Centres, only two had survived in the entire NATO area and the subordinate C2 nodes were national assets, not necessarily commanded by NATO. It would not be right to just blame NATO, but as NATO mainly provides the C2 backbone and it is the countries that provide the forces, all of the member states just reduced defence budgets and with that their forces. This was a trend that did not break until 2014.[2] In general, the European militaries in NATO shrunk from fully capable armed forces, able to counter an all-out threat to Europe (Article 5 scenario), to small independent armed forces providing units only to fulfil a NATO request for troops to support a confined 'out of area' operation. In fact, this became NATO policy. Although regularly discussed within military circles, this remained the policy until the Warsaw Summit in 2016.[3]

Along with these large cuts in C2 nodes, NATO practically doubled its European territory towards the east with the incorporation of new member states joining NATO. In these former Warsaw-Pact countries, first priority for investment and improvements in the area of defence was not the expensive high-tech air defence systems that were commonplace in the west. The resources that were available originated from former Soviet stocks and were in no way technically compatible with the 'western' equipment used by the 'older' NATO members[4]. The big exceptions in real NATO capability, are investments in NATO's Ballistic Missile Defence (BMD) and the Air Ground Surveillance (AGS) project. For BMD it is worth noting that this is focused on a specific threat from the Middle East region, dealing solely with ballistic missiles with a certain range, threatening NATO's European territory. Although BMD is a part of NATO Integrated Air & Missile Defence (IAMD), it is not only an important addition to the capability, but it also brings extra complexity to the air battle and therefore requires integration into NATO's IAMD training protocols. There were other investments within NATO, but none that expanded existing fighting capabilities and were mainly limited to the replacement of obsolete systems.

It was not until the United States, in 2018, rather explicitly made it clear to their NATO allies that there had to be a better 'burden-sharing' (as already pronounced during the 2014 Wales summit)[5] before NATO allies started to react, albeit step-by-step. Currently, it is challenging for NATO to perform IAMD within its 'newly' (since 1991) obtained territory. The nations of the Alliance still uphold their surveillance and tracking responsibilities though, which together with the AWACS (and the upcoming AGS) is enough to provide full airspace surveillance capability for its area of responsibility. The full system of IAMD not only lacks a C2 capability and air defence resources, but the interoperability challenges NATO faces between these scarcely available resources are quite challenging. It is therefore very important to keep or

bring these scarce resources (low quantity) to a high level of readiness and training (high quality), to at least enable maximum efficiency.

New Threats to NATO and Other Wake-up Calls

One of the first omens indicating change was the conflict in South Ossetia in 2008. Torn between a Russian history and a hope for a more western future, a civil conflict offered Russia the opportunity to show that the days when it could be ignored were over. Russia displayed its high-tech weaponry and demonstrated that it was well capable of modern warfare in the air, on the ground, and within the electromagnetic spectrum. Russia was no longer to be kept out of the geopolitical equation. Experts stated that a freeze of the situation at the end of 2008 was the best outcome which could be achieved by the West.[6]

In Ukraine during 2013, internal differences of opinion over whether to take a western/European course for the country's future or to remain loyal to the old supporter, Russia, led to a political dilemma. This dilemma led to a conflict in which people in eastern Ukraine (east of the Dnipro River) and the Crimea (the vast majority of people living there are ethnic Russians) stated a preference for Russian governance. On 7 April, Eastern Ukraine declared itself 'The Donetsk People's Republic'. Russia in the meantime played its role as a world power, by placing large troop concentrations close to the Ukraine's borders. During the summer of 2014, a short civil-war for Eastern Ukraine was fought, where Russian military knowledge and power allegedly stopped the Ukrainian offensive and secured the Donetsk People's Republic. Again, Russia showed it was back in the game.

In the above-mentioned situations in the European region, but more recently in the Syrian theatre, Russia has also demonstrated its twenty-first century, updated-military power by fully integrating joint operations, high-tech weaponry and superb coordination with hybrid warfare tactics. This reinforced Russia as a player on the world stage, which has to be taken into account.

With an underlying terrorist threat, the revival of Russia as a world power, the influence of rapid technological developments in general and an apparent growing instability worldwide, NATO's security situation has dramatically changed. For air defence specifically, the rapid proliferation of missile technology, (near) future hypersonic threats like upcoming cruise- and glide-vehicles as well as (swarming) drones only adds extra challenges that will require an adequate air defence to answer as well.

In order to cope with the changing situation, NATO needs to adapt. Air defence is a complex technological and procedural part of our defence. Incidents like the downing of Flight MH-17 in Ukraine and UIA Flight 752 in Iran[7] showed what can happen when air defence forces are not properly controlled or trained. Air defence is often the first line of defence in a conflict and thus will require high-training standard and readiness.

NATO's Training Philosophy and the Tactical Evaluation Programme (TACEVAL)

Exercises

A brief look at NATO's exercise philosophy includes exercises conducted in three forms: a Live Exercise (LIVEX), Command Post Exercise (CPX), or an Exercise Study. A LIVEX is an exercise in which actual forces participate. A CPX is a headquarters exercise involving commanders and their staffs, and communications within and between participating headquarters, in which NATO as well as opposing forces are simulated. An Exercise Study is an activity which may take the form of a map exercise, a war game, a series of lectures, a discussion group, or an operational analysis. NATO's exercise programme planning covers a period of six years, with detailed programming for the first two calendar years, and outline programming for the following four calendar years.[8,9]

NATO's focus in the last twenty-five years has not been on large scale conflict, the traditional Article 5 Collective Defence scenarios, but rather on Smaller Joint Operations (SJOs) at the edges of NATO territory or

'non-article 5 Crisis Response' exercises. In general, the assumption was that the adversary would have some military potential, but would always be at a lower level than NATO's capabilities. It is only in the last few years that NATO has started to look at how it would operate in a so-called 'near-peer' scenario and how to operate against an adversary with a similar capability. Exercise Trident Juncture 2017 (Joint Force Command level) clearly demonstrated the challenges accompanying such scenarios. One thing to consider in these scenarios is that numbers do matter, since attrition plays an important part in the campaign outcome. NATO does not seem used to such conflicts anymore, after a time when we could choose the option of 'low-risk' scenarios. A near-peer scenario will not offer that option.

Air Power in Exercises

Air defence is an essential part of 'Air Power'. Air Power in NATO is managed by NATO AIRCOM. IAMD, however, is a joint operation, and so includes assets of the Land and Maritime Command as well. IAMD in joint operations requires solid planning in advance, backed up by well-developed Doctrine, Tactics, Techniques and Procedures. In addition, coordination during the execution of air (defence) operations is absolutely essential. It is obvious that this level of planning and coordination requires solid training.

NATO AIRCOM has a very busy exercise schedule. Looking closely, it reveals multiple smaller exercises that comprise either smaller tactical units or small geographical areas. The exception is the exercise series Ramstein Ambition[10], whose objective is to train the AIRCOM 'war-staff' on the Joint Force Air Component (JFAC) procedures. This NATO Command Structure JFAC is not a standing NATO organization. It comprises a 'backbone' that works its peacetime duties at AIRCOM, but which is dependent on a substantial amount of additional support from throughout the NATO Command Structure, as well as from NATO countries to man and augment the headquarters. As a matter of fact, the majority of possible JFAC's in NATO are national assets. In essence,

NATO AIR has one AIR Command and Control (Air C2) exercise per year. It is clear that the complex art of IAMD performed by a composite JFAC requires more solid training.

Exercises are not limited to NATO initiatives. There are a number of NATO nations that provide outstanding training possibilities in the domain of IAMD. Next to the NATO AIR exercises, NATO C2 entities support or play an important role in (multi-) national exercises of member states. Therefore, for NATO training, access to NATO exercises and Allied (bi- multi-) National Exercises is available. At this moment SHAPE and AIRCOM are showing an increased interest in these exercises as a vehicle for their training objectives.

As mentioned above, NATO Exercise Ramstein Ambition is an excellent venue for JFAC training, however the subordinate unit levels are not involved, although there are a number of national exercises where that level is trained and triggered. The most well-known of these are without a doubt the Netherlands-German initiative Joint Project Optic Windmill[11,12] and the Eastern Europe originated SBAD exercise 'Tobruk Legacy'[13]. Both exercises, for all their success, are highly dependent on NATO (AIRCOM) support to create a realistic environment.

The TACEVAL Programme

For IAMD units Combat Enhancement Training or Force Integration Training is hardly an option as they will be part of a first line of defence in any conflict. IAMD units need to be prepared and an audit (Tactical Evaluation), announced or not, would be an outstanding verification tool for NATO Commanders.

During the cold war, in order to keep its air defence forces at a high standard, NATO (in 1960) developed the Tactical Evaluation (TACEVAL) system. A standing NATO evaluation team, together with experienced allied subject matter experts, regularly checked the readiness, resources and training standards of NATO's units. Next to air defence capabilities, this evaluation also included Force Protection (Survival-To-Operate) and Logistical Support. The Air troops consisted of: Air Command and Control units (Air Surveillance and Control System); flying units (NATO commanded airfields on the West-European continent); and all Ground Based Air Defence Units in the SAM belt.[14] After the Cold War, as NATO decreased its NATINADS, the TACEVAL branch shrank as well. However, TACEVAL maintained a minimum capability within AIRCOM. Although mandatory for all forces offered to NATO, not all of these forces are currently NATO-qualified or are undertaking this evaluation. The strength of a TACEVAL team is that it serves as an audit team for SACEUR. It provides a substantiated finding of the state of NATO's tactical air forces, or at least those elements that were offered for evaluation. The days when all NATO command forces could receive an unannounced readiness evaluation and were subject to a yearly tactical evaluation are in the past. This would require a significant expansion of the TACEVAL branch and a mandatory TACEVAL for all forces offered to NATO AIRCOM. Nevertheless, since the certification of the troops offered to NATO is a national responsibility, NATO requires an audit team to verify the status of these troops. The NATO TACEVAL system was created for that verification and with some investment could easily serve as NATO's audit team. An audit team is an essential part of quality control within any organization.

Assessment

With the significant reduction of forces after the fall of the iron curtain, both NATO and the individual NATO member countries (perhaps spoiled by air superiority in the last thirty years), seemed to have lost focus on the importance IAMD brings to the Defensive Counter Air role. With NATO's AOR having grown significantly in the years since the Cold War, air defence has become much more important and the focus on its sustainability and standards, particularly regarding IAMD, have been challenged by lack of investment and training opportunities.

Recent events in Eastern Europe and Syria have forced the consideration of another approach for NATO military capabilities.

NATO has training events and capabilities in order to keep its air forces at the NATO standard for all of the out-of-area operations that have taken place in the last three decades. However, in a near-peer scenario,

numbers will count for more since attrition in these scenarios is considered normal practise. Since numbers will count again and due to the low number of NATO forces, the quality of our forces will have to make up the difference.

Air defence is a complex technological and procedural part of our defence. A successful execution of the IAMD mission depends heavily on interoperability, connectivity, and a shared common understanding of doctrine, concepts of operation, tactics, techniques and procedures. A complex mission such as IAMD requires extensive training of all entities involved, from the strategic level down to the tactical level. The training will need to be fully integrated, as the battle will be integrated.

For the NATO commanders to watch over the training status of NATO air defence units, a recurring NATO audit is necessary. This also puts more emphasis on each member nation's own responsibility to provide NATO with well-trained units. The TACEVAL system has been proven as a great tool to verify this.

Proposals and Recommendations

Although the NATO training calendar seems adequately populated, there is a significant need for more joint and integrated air defence training. NATO should reinstate its large scale Joint Force exercises to train Headquarters and unit interactions. In between these Joint Force exercises, Air Command should perform an annual exercise in which the Land and Maritime (SBAD) forces are integrated, since the air and missile defence battle is by definition a joint battle. These annual exercises do not necessarily have to incorporate large troop formations as in a LIVEX (like Joint Force exercises), but they should not be limited to CPX only. A hybrid form where operational level decision-makers are challenged by the execution of their plans by the war-fighters at the tactical unit level, and vice versa, would work well. National initiatives can play an important role in NATO's AIR training. Exercises like Joint Project Optic Windmill and Tobruk Legacy, but only with the robust (fit to the scenario) participation of the NATO Command Structure, could be a solid basis for IAMD training.

NATO could make use of its proven, 'old-school' training capabilities through adaptions to current requirements. The backbone of IAMD is still present in the NATO Command Structure. It will require funding and manpower and will certainly require some time, but NATO is ready for a renaissance of its integrated air defence system.

1. Blazing Skies, Col R. Nederlof, 2002.
2. NATO Wales Summit Declaration, Sep. 2014.
3. NATO Warsaw Summit Declaration, Jul. 2016.
4. NIAG SG 220 Study on GBAD operations in the 21st century.
5. Ibid. 2.
6. https://www.nemokennislink.nl/publicaties/zuid-ossetie-wordt-wereldnieuws/
7. JDW 29 Jan. 2020.
8. SACEUR Annual Guidance for Education and Training.
9. https://shape.nato.int/exercises
10. https://shape.nato.int/news-archive/2017/exercise-ramstein-ambition-underway-at-allied-air-command
11. https://www.facebook.com/JPOW2019/
12. https://www.japcc.org/joint-project-optic-windmill/
13. https://www.defence24.com/nato-holds-a-major-air-defence-exercise-in-poland-tobruq-legacy-19
14. During the cold the SAM-belt was an important part of NATO's high alert DCA capability (figure on p. 80).

Lieutenant Colonel G. W. 'Berry' Pronk

has served for nearly 40 years in the Dutch armed forces. He served in various national Command and training positions in the realm of Ground Based Air Defence as well as staff positions at the Royal Netherlands Air Force Command and The Royal Netherlands Army Command. Internationally he served at the former HQ Extended Air Defence Task Force (with US Army and German Airforce) and at the German Air Force Forces Command, as well as Section Chief Air Operations at J3, NATO SHAPE. Currently the author holds the position as Subject Matter Expert for Surface Based Air and Missile Defence at the Joint Air Power Competence Centre in Kalkar, Germany.

NATO SEAD Course

Repairing the NATO SEAD Knowledge Gap

By Squadron Leader David Tucker, UK AF, CAOC-T and Course Director

Background

It has been widely acknowledged that the past two decades have been bad for Air Electronic Warfare (EW) development owing to the West's deep involvement in counter-insurgency in Afghanistan and the Middle-East. While advances in flare technology and Infrared Radiation (IR) countermeasures have continued, the absence of any real radar-laid threat has led to reduced investments and consequently a lack of development in radar countermeasures. Alongside this, there has been a reduction in the number of specialized Suppression of Enemy Air Defence (SEAD) platforms. When faced with a campaign against a near-peer adversary, it was assumed that a major cause of attrition to friendly Air Power would be Surface-to-Air Missile (SAM) defences. Russia has some of the best SAM systems and has exported them widely. The SEAD mission was created to address this threat during the Vietnam War, and reached a high level of capability by the time of the 2003 invasion of Iraq. However, since that time, the number of SEAD platforms available to NATO has reduced markedly. A side effect of this is that fewer people are involved in the SEAD mission today, leading to a reduction in the general level of knowledge about SEAD within air staffs.[1]

The Necessity

The article 'Electronic Warfare – The Forgotten Discipline'[2] identified the need for a refocus on EW. In addition, Aerospace Capability Group 3 (ACG3), in its 2018 SEAD Concept of Employment (CONEMP),[3] identified the alliance's shortfalls in the SEAD area. One highlighted deficit was the need to improve the understanding of SEAD in the Air Component's Command and Control and Planning organizations, an essential capability also identified in the 2019 Airborne Electronic Attack CONEMP.[4] With this in mind, the requirement for a course to educate NATO staff officers was developed at the Headquarters of Allied Air Command (HQ AIRCOM), and progressed through System's Approach to Training Global Programming, leading to the decision to develop a SEAD Orientation Course by HQ AIRCOM in cooperation with the NATO School Oberammergau (NSO), to be delivered by the NSO. The SEAD orientation course was introduced in June 2019.

The Course

The Pilot XX-157 SEAD Orientation Course took place in June 2019 with eight experienced staff officers as trial students. The syllabus contained diverse lectures

1st NATO Suppression of Enemy Air Defences (SEAD) Course, 17–20 June 2019. © NATO School Oberammergau

covering Integrated Air Defence System (IADS), Anti-Access/Area Denial (A2AD), SEAD and EW doctrine, the Jointness of SEAD, Multi-Domain Operations and a number of capability briefs. Contributions to the course came from a diverse range of speakers, Capability Briefs were given by Boeing EA-18G 'Growler' and Tornado Electronic Combat/Reconnaissance (ECR) crews; Staff Officers from HQ AIRCOM and Combined Air Operations Centres (CAOCs) contributed lectures on Doctrine, Information Operations and planning for SEAD Operations. Test Pilots provided briefings on emerging technology. It is planned to introduce further capability briefs, for example on the F16CM, and SEAD enablers such as Electronic Intelligence (ELINT) platforms for future courses while retaining the solid doctrine and planning fundamentals. In addition, briefings on the contribution by other components to SEAD will be introduced. The Pilot Course was well received by the trial students and NSO standards.

Invaluable feedback was received enabling the course to be improved for implementation. The main addition will be syndicate planning work using a NATO Operational training scenario to solidify students' understanding of the principles taught in the course, which will be five days long. It will be run by the NSO with HQ AIRCOM acting as the Office of Primary Responsibility (OPR). The course planned for 22–26 June 2020 has had to be cancelled owing to the COVID-19 Crisis. However, it is expected that the course will run in June 2021, and applications are invited from those who wish to increase their knowledge of SEAD operations. ●

1. For a detailed analysis of NATO's dwindling SEAD capabilities and the need to educate Alliance C2 on the Jointness of SEAD, see SEAD Operations of the Future – The Necessity of Jointness, JAPCC Journal No 26, Col J. Speed and Lt Col P. Stathopoulos.
2. Cdr M. v. Spreckelsen, 'Electronic Warfare – The Forgotten Discipline', in JAPCC Journal Edition 27, 2018, p. 41–45.
3. NATO's Suppression of Enemy Air Defences Concept of Employment, 14 Sep. 18.
4. NATO's Airborne Electronic Attack Concept of Employment, 12 Aug. 19.

Squadron Leader David Tucker

has served in the Royal Air Force (RAF) since 1987. He spent most of his career as a Weapons Systems Officer on the RAF Tornado GR1 and GR4, and also completed an Exchange Tour with the German Air Force flying the Tornado ECR. He completed an MLitt in Strategic Studies at the University of Aberdeen in 2004, winning the Gordon Shephard Memorial prize that year for his essay published in the Air Power Review on European Defence Integration. He has recently finished a staff appointment at HQ Allied Air Command in Ramstein and is currently serving in CAOC Torrejon.

From Ground to Exosphere

The Joint Air Power Competence Centre 2005 to 2020

In December 2019, at the close of its 15th year of operation, the JAPCC underwent a Periodic Assessment (PA)*, conducted by Allied Command Transformation (ACT); this assessment was the JAPCC's second, the first having been conducted in 2013. Preparing for a PA takes a huge amount of work and crucially, needs the staff of a Centre of Excellence (COE) to properly consider the question: what have they and the organization *really* achieved? To answer this question required a 'deep dive' into all that the JAPCC had done over the past 7-years, for whom and to what effect? In delivering this work, successfully passing the PA and ultimately being re-accredited as a NATO COE, the JAPCC was forced to undertake a thorough review of itself.

Having twice now captured so much information about the JAPCC, the logical progression was to share this information with Sponsoring Nations and the JAPCC's Customer Base. The challenge though, was how to combine two rather large documents (the PA Assessment Questionnaires compiled in 2013 and 2019 for ACT) into a more easily consumed and hence useful reference? The answer is that we are developing a new White Paper which currently has the working title *'From Ground to Exosphere – The Joint Air Power Competence Centre 2005 to 2020'.* The intent is to publish a simple overview document in time for our Conference in December of 2020 and then publish the main document in the early part of 2021.

The White Paper will briefly describe what COEs are, describe the JAPCC itself and then major on two primary areas. Firstly, the JAPCC's enduring outputs – those major activities that occur regularly and are the bedrock of the JAPCC's Air and Space Power transformational activity. Second, the more dynamic and ever-changing activities or projects that feed the effective and resource-efficient delivery of Alliance Air and Space Power. These activities include, but are by no means limited to, direct support to operations, policy and concept development, exercise support, delivery of training, lessons learned etc. Indeed, anything that helps improve current, or likely future, delivery of effects from Air and Space.

If anyone has ever wondered what the JAPCC is or what it does and why it should be supported, this publication will answer those questions. Not only is this White Paper a historical record of the JAPCC's 15-year history to date, but it also explains why NATO needs a dedicated Joint Air and Space Power Warfare Centre. Furthermore, we believe that it demonstrates that the JAPCC delivers value way above any resource-cost considerations; the JAPCC is both extremely effective and at the same time, incredibly resource-efficient. The question posed, therefore, should not be why should nations invest or continue to invest but rather, why would any nation *not* want to invest?

No Nation that considers itself a true Air and Space Power player would entertain divesting itself of its National Air (and/or Space) Warfare Centre capability, therefore, the Alliance cannot expect to function without its integral Air and Space Warfare Centre – the JAPCC. This White Paper sets out to reinforce this point, and like all JAPCC publications, the reader will be the judge. Readers are encouraged to join the debate, and we look forward to hearing your questions or comments! ●

* All NATO accredited Centres of Excellence (COE) are assessed periodically by HQ SACT (COE Programme Development Branch – CPD) to ensure they meet the criteria for a NATO accredited COE.

Space Branch

The increasing permeation in modern warfare of Data, Products, and Services (DPS) provided by Space-based capabilities is changing the way in which NATO plans and conducts operations and strengthens their deterrence and defence posture. In particular, the evolutionary changes within the last decade have resulted in the recognition of Space as an Operational Domain by the leaders of the Alliance at the NATO London Summit in December 2019.

The JAPCC, as NATO's catalyst for the improvement and transformation of Joint Air and Space Power, has been active in NATO Space-related activities since its founding in 2005. Similarly, Space Support in Operations has played a prominent role within this Centre of Excellence since its inception by SACT, with the JAPCC being appointed as the Department Head to manage Education and Training in this discipline in 2016. The JAPCC Space SMEs have participated in the multifaceted NATO activities regarding the integration of Space aspects in Operations, beginning in 2007 with a *NATO Space Operations Assessment* Study that was conducted on request of HQ SACT and published in 2009. This study identified gaps and provided recommendations which informed a decade of discussion, as well as (among others) a JAPCC White-paper *Filling the Vacuum* which provided a framework for a NATO Space Policy. Both papers influenced the preparation of a NATO Overarching Policy for Space in June 2019, and the aforementioned Operational Domain recognition. These recent developments portend a rapidly-increasing workload for Space-related work on behalf of the Alliance.

Following up on the addition of a fourth Space SME post to the JAPCC in 2019, the JAPCC's 2020 Steering and Senior Resource Committees approved the re-organization of the COE's structure to include a Space Branch with a total of seven Space-related posts. This branch reflects the growing recognition of Space by NATO and is established to respond more effectively and efficiently to the demands of the Alliance. Further growth is not excluded, but will be requirements-based and all NATO and partner nations are invited to collaborate with the multinational team at the JAPCC to help shape the further development of assured, resilient, reliable and interoperable Space services and support to the Alliance and its member nations. ●

Sunset March

In the city of Nijmegen, there is a daily tribute to the Allied soldiers who fought for the liberation of The Netherlands in World War II; particularly for those soldiers who lost their lives crossing the Waal River to capture the Nijmegen bridge during Operation Market Garden. In 2013, the city of Nijmegen finished the construction of a new bridge called 'De Oversteek' ('the Crossing'). It was constructed close to the area where the US 82nd Airborne crossed the river on 20 September 1944, in a battle depicted in the 1977 film *A Bridge Too Far*. 48 Allied soldiers lost their lives during the 'Waal-crossing' and they are commemorated by 48 pairs of street lights on this bridge. At sunset, these sets of street lights are, pair by pair, ignited at a slow marching pace, guiding a procession that takes nearly 12 minutes. Each and every night a veteran walks the Sunset March exactly at sunset in a pace according to the ignition of the lights.

The Dutch Honorary Consul in Kleve invited all personnel from the Kalkar and Uedem barracks to walk the Sunset March, including laying of a wreath and a meeting with the Mayor of Nijmegen, on 22 February 2020. This date is of particular importance as this was the day in 1945 that Allied Bombers inadvertently bombed Nijmegen instead of their original target, Kleve. This bombardment destroyed the historical heart of the city.

Participating in the Sunset March on the 22nd February of each year has become a JAPCC tradition in the past years. ●

JAPCC Social Media Campaign

Promoting Effective Solutions for NATO's Air & Space Power Challenges

The focus of the JAPCC Social Media Campaign is to provide increased awareness of the myriad activities of JAPCC assigned personnel in advancing effective solutions to Air & Space Power challenges to key decision-makers in order to safeguard NATO and the Nations' interests. This awareness generally falls into one of two categories; 1. Informing interested parties of activities sponsored or participated in by JAPCC Personnel, or 2. Promoting independent thought and analysis pieces generated in or through the JAPCC.

At the beginning of 2020 the JAPCC celebrated its 15th Anniversary as NATO's first accredited Centre of Excellence, with a specific focus on Air & Space Power issues. This means that, like many similar institutions, the JAPCC is older than some of the social media platforms it currently utilizes to promote its efforts. Still the JAPCC is embracing the Information Age, with an ever-increasing presence on social media. Besides its own website (www.japcc.org), the JAPCC is increasingly using its presence on Facebook, LinkedIn, and Twitter to spread its good word.

Facebook posts often equate to a more personal touch in addition to the publishing of news related to activities and analysis. Reaching almost 30,000 people with its posts in 2019, these posts at times also touched upon issues closer to home, such as, morale events or simply aesthetic appreciation of military aircraft executing their missions. With the number of followers having increased 30% in the last year, we seem to have found a comfortable niche to satisfy professional military and amateur Air and Space Power enthusiasts alike.

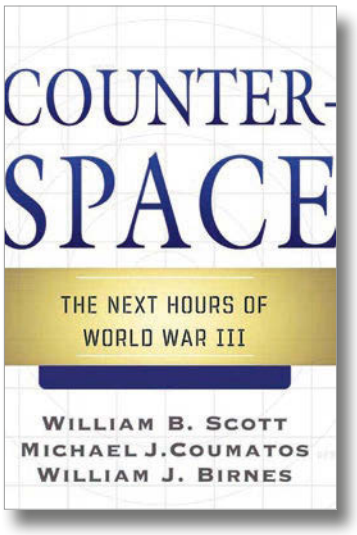
Twitter provides access to a platform with limited characters but seemingly limitless reach; in 2019 JAPCC Tweets reached nearly 250,000 people. Often focused on links to interest items written within the JAPCC, about issues important to the JAPCC, or even outside articles about the JAPCC, Twitter has provided a platform for quick messaging in an ever-evolving world … and with JAPCC Twitter followers up over 50%, we are keeping pace.

LinkedIn posts focus is on promoting professional conversations and collaboration. As with the other platforms, LinkedIn provides a vessel for the further distribution of JAPCC Journal Articles, White Papers, Reports, and Conference Read-Ahead Think Pieces. With more available space for comments and reactions, in a professional forum, it's no wonder the JAPCC has more than doubled (>110%) its number of followers, reaching nearly 58,000 people with its posts, in the past year.

The collective successes of the Social Media Campaign helped the JAPCC host its largest-ever Air & Space Power Conference in 2019, and directly led to the submission of Read-Ahead Paper offerings in advance of the 2020 Conference at 3 times the usual rate; with monographs from across Europe, Australia, the Middle East, and North and South America. As JAPCC's Social Media presence grows, with your assistance, we remain focused on increasing awareness of our myriad activities, and we also welcome the opportunity for followers to provide feedback, including ideas for solutions that might warrant JAPCC involvement.

Please follow JAPCC on:
Facebook: @JointAirPowerCompetenceCentre;
Twitter: @JointAirPower;
LinkedIn: @JAPCC.

‘Counter Space: The Next Hours of World War III’



By Michael J. Coumatos, William B. Scott, William J. Birnes; Forge Books; October 2009

Reviewed by:

Lt Col Tim Vasen, GE A, JAPCC

Counter Space is a novelistic, nonfiction book based on war-gaming findings. It is the follow on book of Space Wars (April 2007 written by the same author group) where terroristic attacks have degraded the critical Space Support services.

This book describes potential outcomes and actions committed by other actors who now use the gaps in the security architecture. What would happen if a rogue nation explodes a nuclear weapon in space? What would happen if another rogue nation tries to attack a long-time enemy that relied on the degraded western space services for self-defence? How could terrorists use the situation to their advantage?

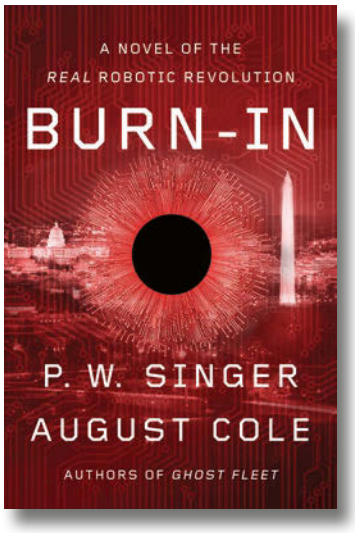
Finally, what if it comes to a conflict with a peer opponent who relies on its own space services that have also been degraded? It shows how a simple situation could escalate if both protagonists are not able to verify the situation. The existing developed and proven security procedures might not be usable. If then, due to degraded C2 systems decision-makers have to decide locally it could bring the world to the threshold of World War III.

The authors describe situations that have been threatening concepts since 2009. Within the worldwide increased importance of space in security architectures as well as the ongoing technical developments these concepts have become reality today. ●

‘Burn-In: A Novel of the Real Robotic Revolution’

It’s not data, statistics, or system specifications, but rather the story that allows us to connect with, and internalize, new information. Through stories we are able to comprehend and adapt to the evolving world around us and find a path forward toward an uncertain future. For military operators and planners bombarded by capability charts, risk assessments, and courses of action, the ability to delve through the noise and gain a true appreciation of the situation is vital to achieving mission success. Based in-part upon real-world research examining Artificial Intelligence and its potential applications, *Burn-In* provides fictional interpretation (the story) of how new technologies and techniques might be used in the near future.

P. W. Singer and August Cole once again strike home with a novel that takes the myriad challenges posed by the information age and personalizes them. *Burn-In* distills emerging technologies into a narrative which allows for a greater appreciation of the new reality they bring, including the threats and opportunities they present. The storyline utilized by the authors allows the reader to open their minds to possible ways in which new technologies can be leveraged, a crucial capability for any professional military thinker. After all, as the book’s protagonist Lara Keegan grudgingly admits, ‘there’s no fighting change. We have to embrace it.’ ●



By P. W. Singer, August Cole; Houghton Mifflin Harcourt; May 2020

Reviewed by:

Lt Col Henry Heren, US AF, JAPCC

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